BMP

Best Management Practices for Landscape Fertilizer Use on Nantucket Island

Prepared by The Article 68 Work Group

2010-2011

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BEST MANAGEMENT PRACTICES FOR LANDSCAPE FERTILIZER USE ON NANTUCKET ISLAND

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Preface

The following Best Management Practices Plan (BMP) is broken down into sections that contain comprehensive information on soil fertility and landscape fertilizer use on Nantucket. Sections were drafted by members of the Article 68 Work Group and by landscape professionals of diverse backgrounds and levels of education, expertise and experience.

As I read through this document, it strikes me over and over how closely interrelated each aspect of turf and plant dynamics is to soil chemistry, climate, and cultural practices.

Reading through the BMP, one section at a time, can be compared to looking at or studying individual trees one by one in the forest. It's important not to lose sight of the forest, as a whole, but also not to over simplify complex science. The 'forest' in this case can be considered not only an individual lawn or garden landscape, but in fact, the whole island.

The BMP attempts to explain the complex science of plant and soil dynamics in terms that are accessible to landscape professionals as well as interested homeowners. It reminds us that all is interrelated: climate, water and nutrient cycles, turf, gardens, soil, groundwater, and our ponds, wetlands, and harbors.

With the risk of getting lost in 'the forest' of the BMP, the following is a summary of key factors that influence correct rates and timing of fertilizer applications to Nantucket's man-made landscapes.

1- The importance of a soil test in determining and correcting soil pH, nutrient deficiencies, and the amount of organic matter content.
2- Climate: Fertilizers applied to turf or plants when soil temperature is below 55 degrees F are not readily assimilated by plants, and are thus likely to end up in our harbors or ponds, or groundwater, threatening aquatic and human health.
3- The importance of organic matter content in soils and how that influences nutrient availability and 'builds' healthy soil.
4- The role of mowing height, not less than 2 inches, and frequency, the one-third rule, in promoting and maintaining healthy turf.
5- The importance of returning clippings to recycle nutrients and increase soil organic matter content.
6- The no-fertilizer option; i.e. natural landscapes where growth is in equilibrium with nutrients from fallen vegetation.

If everyone who applies fertilizers to turf or garden plants on Nantucket applies the information in this BMP to their practices, the threat of landscape-related fertilizers entering ground water, ponds and our harbors should be significantly reduced.

Lucinda Young, Chair, Article 68 Work Group

Section 1

Introduction

The purpose of this Best Management Practices Plan (BMP) for Nantucket is to provide science-based fertilizer guidelines and other landscape practices, that, when followed, reduce the loss of soil nutrients from excessive, incorrectly timed, and inappropriate fertilizers. On Nantucket, lost nutrients find their way rapidly to the waters, harbors, ponds, and streams where they may cause contamination that is harmful to aquatic organisms as well as human health and welfare.

Objectives of this BMP are:

- To provide landscape professionals and homeowners information for making environmentally sound landscaping decisions that take Nantucket's unique conditions and natural resources into consideration;
- To promote the protection of water resources while maintaining healthy and vibrant ornamental landscapes;
- To reduce the amount of fertilizer use by promoting cultural practices that help build a healthy soil ecosystem;
- To offer site planning guidelines and ecological restoration suggestions that help reduce the total area, island-wide, of fertilizer-dependent landscapes; and
- To provide guidance for routine fertilizer maintenance of lawns and gardens on Nantucket.

In 2010, the Nantucket Annual Town Meeting authorized the Board of Selectmen (BOS) to introduce legislation to the Massachusetts State Legislature through the Home-Rule Petition (HRP) process to regulate the use of fertilizers in the Town and County of Nantucket. To assist in the process, the BOS appointed the Article 68 Work Group (WG) comprised of representatives from interested groups and communities. The WG was charged to recommend constructive changes in perfecting the language of the proposed HRP legislation and to develop a comprehensive plan to reduce the amount of nitrogen and phosphorus contributed by landscape fertilizers in our waters. The WG concluded that, as the basis of its recommendations, it would create a Best Management Practices Plan (BMP) specific to Nantucket's climate and soil conditions as an educational document that incorporates the latest turf and soil science for safer and more effective landscape fertilizer management on Nantucket. The principles contained in the BMP would provide a foundation for the regulatory package developed for the HRP and for any subsequent use by Nantucket's Board of Health.

Nantucket's glacial soils are dominated by deep sands and gravels with low organic-matter content. These soils readily allow water to infiltrate and are particularly prone to leaching of fertilizer and other pollutants. Leaching is the loss of nutrient from the soil by water-based dissolution and transport. Nitrogen that reaches our waters comes from a variety of sources. Although the largest percentage comes from atmospheric deposition of combustion-caused nitrates (automobile and power-plant exhaust), other human-related land uses contribute a significant amount. Exact percentages are near impossible to measure, but among the major nitrogen contributors from land-based uses, are septic systems, road and roof runoff, and excess or inappropriately applied fertilizers from both agricultural and landscape practices. A small percentage comes from the excreta of wildlife. Nutrient leaching from improper fertilizer use is one of the controllable contributing factors to the degradation of our groundwater and surface water bodies. Contamination of the island's aquifer and wetlands threatens our fisheries and tourism industries, and ultimately public health. The control of fertilizer application, along with well-understood controls on septic and sewer systems, will help reduce the degradation of the critical resources of Nantucket's waters.

In recent decades, Nantucket has experienced significant land development resulting in increased nitrogen inputs from land-based uses including many high maintenance lawns and gardens that are fertilized regularly. Continued development of the island and increases in atmospheric deposition further threaten our water resources and demonstrate the need for increased awareness of landscape choices and practices that reduce both nitrogen and phosphorus inputs without sacrificing the appeal of well maintained landscapes or the health of our water resources.

Nantucket Island has abundant freshwater and saltwater resources. Nitrogen is the limiting nutrient for saltwater and some freshwater systems while phosphorus is most often the limiting nutrient for freshwater systems. Excessive concentrations of nitrogen in saltwater and phosphorus in freshwater will facilitate algae blooms and various levels of eutrophication. These algal blooms can be toxic to marine life and, in some cases, to humans, pets, and livestock.

The Work Group assigned a subgroup consisting of professional island landscapers, the Nantucket Golf Club golf course manager, an irrigation specialist, and the director of the Nantucket Land Council, to review the "2003 BMP for Turf, Tree and Shrub Fertilization on Nantucket Island", an earlier document produced by the Nantucket Landscape Association, and to make recommendations for updating and improving it. This resulting document incorporates and expands upon much of the previous Nantucket-based material with added guidelines from a number of other relevant sources. The recommendations and guidelines presented in this document reflect the experience and knowledge of Nantucket landscape professionals and have been peer reviewed by turf and soil scientists. These reviewers are identified and thanked in the list of Acknowledgements; they voluntarily gave invaluable service to Nantucket and we are in their debt.

It is estimated that approximately 10 to 19 percent of the nitrogen applied to turf on Cape Cod soils, similar to Nantucket's, eventually leaches into groundwater (Petrovic, 2008, Horsely Witten Group, 2009). It is likely that nitrogen loss rates may be higher for ornamental plantings compared with turf (Cisar et al., 2003, Erickson et al., 2001). Leachate that reaches subsurface ground water can percolate downward to contaminate aquifers, which are Nantucket's sole source of fresh water, or eventually discharge into receiving wetlands including Nantucket and Madaket Harbors, the great ponds, and the many smaller wetlands found throughout the island.

This BMP is the educational document that provides Nantucket landscape professionals and interested homeowners with the information necessary for effective turf and garden fertilizer management; nonetheless it has the larger aim of protecting our unique water resources. It is derived from documents gathered by other entities interested in managing fertilizer applications, from newly written guidance documents for turfgrass management, from standard textbooks on soil and turf science, from the enormous library of information available from the Natural Resources Conservation Service of the U. S. Department of Agriculture (www.nrcs.usda.gov), from the deep reservoir of experience held by members of the Article 68 Work Group, and from members of the scientific and academic communities who gave freely of their knowledge when reviewing this work. Reference lists are maintained for each Section and a bibliography of important works is at the back of this document.

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Section 2

Nitrogen and Phosphorus and Plant Growth

- **Nitrogen (N) and phosphorus (P) are two essential elements required for plant growth.**
- **Native Nantucket soils are generally low in N but may contain an adequate amount of P.**
- **A soil-test analysis should be used to determine if fertilizer application is necessary to supplement P and add organic matter in intensively managed turf or ornamental plantings. Testing only gives a snapshot of available nitrogen and is not a reliable way to assess N need.**
- **The advantages and disadvantages of slow-release and quick-release fertilizers are discussed.**
- **The advantages and disadvantages of synthetic and organic fertilizers are discussed.**
- **Fertilizer should only be applied during periods of active plant growth to insure efficient uptake by target species and to reduce the potential for runoff and leaching into aquatic resources. Soil temperatures should be above 55^{o} F and adequate moisture should be present when applying fertilizer.**
- **Turf-growth potential models based on historic temperature, precipitation data, and plant growth characteristics can be used as an aid to design effective and efficient fertilizer application programs. A sample model is presented (appendix) that was developed using climate data collected at the Nantucket airport.**

How and when nitrogen, N, and phosphorus, P, are available to and utilized by plants is fundamental to determining when and at what rates to apply these two nutrients for optimum turf and plant growth. The timing of fertilizer applications and climate are directly connected. Nantucket's soil conditions and seasonal weather are key factors for planning annual fertilizer applications to ensure that fertilizer practices will not harm the island's water resources. This section explains the connection of these two important nutrients to Nantucket's seasonal weather patterns. Ensuring that fertilizers are not applied too early in the spring or too late in the fall is fundamental to protecting Nantucket's harbors, ponds, and groundwater.

Nitrogen and Phosphorus Uptake by Plants

Nitrogen is absorbed by plants in two forms: nitrate (NO_3^-) and ammonium (NH_4^+). All sources of nitrogen must eventually be converted to one or both of these forms to be effectively utilized by plants. This is because plant uptake of nutrients depends upon water as the carrier. Nutrients that are not in a water-soluble form may be present but not available to the plant. Elemental nitrogen comprises 79 percent of the earth's atmosphere but this form of N is not of concern to water quality. When, however, it goes through high-temperature processes such as in internal-combustion engines or in power plants, some of that nitrogen is oxidized to the nitrate form where it is now a potential contaminant.

Different forms of nitrogen are found in different portions of the nitrogen cycle, which is a way of describing the fate of nitrogen in and above the earth's surface. Organic N is bound up in complex organic molecules. Most organic forms of nitrogen undergo a process known as mineralization prior to being converted to ammonium and, ultimately, being converted to nitrate. Nitrogen mineralization is a step in the nitrogen cycle and is the result of the breakdown of organic matter by soil organisms, allowing many types of organic forms of nitrogen to be slowly released over time. Quickly available nitrogen, whether synthetic or organic, when applied at excessive rates, can be easily leached from sandy soil. Using organic products that have to go through mineralization or slow-release synthetic products that delay N release can spread the release of nitrogen over a period of time, thereby giving plants a sufficient period to absorb it. Correct application of any nitrogen-containing fertilizer is necessary to prevent overloading the soil and the subsequent leaching, or loss, of this excess.

Phosphorus is essential for plant growth and survival, and is vital for seed germination. A soil test to determine how much phosphorus exists in the soil is mandatory before deciding if any needs to be applied. Not all phosphorus in the soil, however, is available for plant uptake; therefore keeping the soil pH between 6 and 7 will usually help to keep phosphorus available. There are two different procedures for testing phosphorus in soil, the Morgan and the Mehlich III Extracting Solutions. Unfortunately, they lead to very different measurements in the same soil sample. Care should be taken to note which method is used by the soil testing laboratory and to continue to use the same test for subsequent samples.

When available, plants take up phosphate through their roots. The larger and more expansive the root system, the more efficiently the plant takes up phosphorus in the soil. Newly established lawns, because they have limited root systems, may require readily available phosphorus to promote root growth and healthy seedling development. Once a new lawn is established, phosphorus should be applied only as needed.

Being mindful of phosphorus application is very important, especially on Nantucket, because it is the limiting nutrient in fresh water ponds, most of which are located down gradient of both ground and surface water movement. Nantucket's soils may test naturally high in phosphorus, so it is crucial to perform a soil analysis before applying additional phosphorus to the soil.

Organic vs. Synthetic

The terms organic and synthetic, commonly used to describe types of fertilizer, can be somewhat misleading or misinterpreted. This is because these terms do not explain the availability of the nitrogen to plants. A different way to describe fertilizer types, especially in terms of leaching potential, is found in the terms fast-release or water-soluble, and slow-release, which includes water-insoluble and coated fast-release materials.

Nitrogen and phosphorus come from both organic and synthetic sources. Once nitrogen is in a form (nitrate or ammonium) that can be taken up by the plant, there is no difference to the plant between organically or synthetically derived nitrogen. How and when those usable forms of nitrogen become available to the plant is, however, important. Not all organic compounds are truly slow release, and not all synthetic slow-release products are created equal. A detailed description of organic and synthetic sources of nitrogen, phosphorus, and potassium is included in Section 6. "Fertilizer Types and Sources," and its associated appendix. For the purposes of this BMP, mined or "rock" phosphate is grouped with the synthetic sources of phosphorus.

It is now worthwhile to point out both major and subtle differences between the two styles of fertilizer management: organic-based, or synthetic-based. During the nitrogen cycle, most, but not all, organic fertilizers go through the step in the nitrogen cycle called mineralization, a step that inorganic water soluble sources do not take. However, urea, and sources of synthetic slow-release products that use urea as a base go through mineralization as well. For urea, mineralization can be very fast. For some of the slow-release fertilizers using urea as a base, mineralization can be very slow. Mineralization helps many organic fertilizers to slow their release of nitrogen. Some synthetic slow-release fertilizers can match the slow-release characteristics of organic products. Nearly all organic sources of nitrogen contain carbon, some more than others and carbon is essential to the health of a soil. Although some synthetic fertilizers, specifically those containing urea, contain carbon, the actual amount is very low. Organic fertilizers may also contain biostimulants, vitamins, naturally-derived micronutrients, and beneficial bacteria, all of which may contribute to healthy soils and turfgrass

The best technologically advanced slow-release synthetic fertilizers can accurately control the release of nitrogen primarily through variations in soil temperature and moisture. Synthetic fertilizer that contains no phosphorus is readily available. It is important to note that the majority of organic fertilizers contain phosphorus in addition to nitrogen. It is important not to add phosphorus to a soil that does not need it. In such cases, an organic fertilizer should be used that does not contain, or contains very little, phosphorus.

Slow-release nitrogen sources, whether they are organic or synthetic, that are applied at typical rates year after year, can have adverse effects. This slow-release nitrogen can build up in the soils faster than they can be used by the plant. Over a 10-25 year period, the soil can become "saturated'" with this unused nitrogen, and may leach from the soil

Influence of Nantucket's Climate on Nutrient Uptake and Utilization

Nantucket's climate is unique when compared to other communities in the northeast. Because of the surrounding ocean, Nantucket stays cooler later into the spring, relatively cooler than the mainland in the summer, and stays warmer later into the fall. Precipitation events are also different in that the moderating temperatures can turn mainland snow storms to rain on Nantucket; the location of weather fronts – the boundary between and low and high-pressure zones – also may cause rain or snow storms to bypass the Island or <u>vice versa</u>. Although areas around Boston, metropolitan New York, and even Cape Cod can begin to 'green up' in March, Nantucket can be a month or two behind. Local microclimate conditions vary across the island as well. Trees, lawns, and gardens 'green up' earlier in downtown Nantucket, sometimes as much as by several weeks than in outlying areas: 'Sconset being a prime example.

The National Climatic Data Center of NOAA, www.ncdc.noaa.gov, provides a thorough review of the mean (average) temperatures and precipitation amounts as well as of extremes of both for Nantucket. In general, the average temperature on Nantucket does not rise above 55° F until the middle of April and falls below that in early to mid-October. This temperature is the critical value needed for dormant grass to resume growth in the spring or for growing grass to become dormant in the fall. Recommendations made in this BMP for fertilizer application timing are based on these data.

Precipitation amounts may also affect growth, particularly in times of moisture deficiency, i.e. drought. Hot, dry conditions such as are found often in July and August, can substantially retard growth on non-irrigated lawns and gardens. During these periods on sites that are not irrigated, it is necessary to reduce fertilizer applications to prevent a build-up of unused fertilizer in the soil.

Professional fertilizer applicators may wish to develop growth-potential curves for Nantucket that are based on monthly or even daily average temperatures. These curves suggest the percent of growth against the maximum observed in optimum conditions. In cooler or drier periods, growth may be substantially less than seen at warm, moist times. With the growth-potential curves in hand, very specific application amounts of fertilizer can be set that are based on the plant's ability to take up the nutrients. Thus, in the periods of reduced growth, reduced amounts of fertilizer would be applied. Since these curves are also a function of plant species, e.g. warm-season versus cool season grasses, a fuller discussion would be too cumbersome for the purposes of this BMP.

A somewhat more specific analysis of growth versus weather parameters may also distinguish between sub-surface root growth and above-ground shoot growth. These two parts of the plant do not necessarily grow at the same rate. This may be particularly true in the fall, when roots continue to grow even after cooler weather slows shoot growth. This difference may affect the timing of fertilizer applications.

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Section 3

Site Assessment and Planning

- **Site assessment is a preliminary planning stage in the construction process in which the pre-existing physical and biological conditions of a site are identified and used as the basis for developing an environmental site plan that takes best advantage of the existing conditions.**
- **Landscape plans should aim to minimize areas requiring supplemental fertilization and include undisturbed natural areas when possible.**
- **Site assessment should include the following: determination of building and other construction envelopes; soil characteristics as determined by soil tests; land forms and contours; view-sheds; micro climate conditions including winds, temperatures, and sun exposure (also known as aspect); a plant inventory; and areas of critical environmental concern including wetlands and rare plant communities or animal populations.**
- **The site plan for new construction should take advantage of existing landforms; minimize disturbance to lands not slated for development; and conserve topsoil for post construction landscaping.**
- **Site planning for development on existing landscapes should include identification of all of the above conditions plus a post-construction, as-built plan delineating location and type of landscaped areas; irrigation system; other subsurface utilities; a fertilization history; a history of existing and potential problems; and any owner expectations for change and improvement.**

Site assessment is the identification and recording of existing site conditions that are used for environmental site planning including how a property will be designed, developed or renovated, and managed. A commonly used synonym for site conditions is “features;” environmental site planning may be described also as landscape architecture. This section addresses site assessment and planning within the context of reduced fertilizer use and the minimization of resulting detrimental impacts to the environment from excessive fertilizer application.

Identifying Site Conditions

The following site conditions, i.e. features, form the basis for site planning:

- Existing plant communities: including woodlands, shrublands, and grasslands. Particular attention should be paid to rare (endangered and threatened) plant and animal populations and to unwanted invasive plants;
- Environmentally sensitive areas, also known as lands of critical environmental concern, such as wetland resources, as determined by the Nantucket Conservation Commission, and well-recharge zones;
- Soil characteristics as obtained from soil maps (USDA Natural Resources Conservation Service Electronic Soil Survey) and a comprehensive soil test. Refer to Section 4. “Soil Nutrient Analysis: The importance of the Soil Test” for detailed information on soil testing;
- Land-form contours, i.e. the terrain, including steepness, and how they influence drainage patterns and variations in microclimate;
- Prevailing and storm-related winds; weather history can be obtained from the National Weather Service (www.nws.noaa.gov);

- Seasonal patterns of sunlight, i.e. aspect; and
- View-sheds are the nearby landscape elements seen from the property; desirable view sheds are enhanced by low-growth plants whereas undesirable ones are obscured by higher and thicker privacy plantings.

The Town of Nantucket Web GIS Map Page is a useful resource for identifying Nantucket site conditions. http://host.appgeo.com/nantucketma/ .

Site Planning for New Construction

Careful site planning can aid in the reduction of fertilizer use and help reduce related environmental impacts. The following land uses are listed in the order of increasing fertilizer requirements:

- building envelopes: buildings, pavements, and other built structures;
- native or naturalized plant communities;
- minimally managed lawns;
- intensively managed lawns; and
- ornamental plantings.

While all these land uses can be included in an environmentally friendly residential landscape, the inclusion of significant areas of native and naturalized plant communities and minimally managed lawns can greatly reduce fertilizer use, the need for irrigation, construction costs, and maintenance costs. The use of native plants in ornamental plantings also helps to reduce fertilizer use (see Section 13. “Alternative Naturalistic Style Practices”). Native plant communities make excellent natural screens between properties. Maintaining native plant communities and using native plants in ornamental plantings also attracts wildlife such as birds and butterflies and helps to maintain native biodiversity.

Once site planning is complete, it is important to develop construction protocols that minimize disturbance to the landscape. Even areas designated for intensively managed lawns can be damaged by excessive disturbance from heavy equipment or other construction activities. Driving wheeled equipment on topsoil can compact it to the point that the soil’s structure never fully recovers after construction and this leads to poor planting success. Mounding soil around a mature tree deprives its roots of oxygen and leads, ultimately, to the tree’s death. Work areas can be designated with silt fencing, hay bales, or other boundary markers.

Soil is inevitably damaged during construction but some practices can help minimize the damage. Existing vegetation in construction zones should be brush cut and the resulting debris removed from the site. The A-layer of the topsoil, i.e. that uppermost portion containing organic matter, should then be rototilled, stripped from the surface, and stockpiled on site. The depth of the A-layer is easily seen in a small, sample trench, or by taking a soil plug. On Nantucket, this layer is often thin and even absent. This soil can them be returned to disturbed areas post construction. Stockpiling of stripped topsoil in windrows helps protect soil organisms but may increase the area damaged by the soil piles. Planting a cover crop such as winter or annual rye on stockpiled topsoil helps protect the stored soil, provides habitat for valuable soil organisms, reduces loss to erosion by wind and water, and reduces weed establishment.

Once construction activities are completed, the stored topsoil can be returned to the disturbed areas. Air and water movement through the soil profile can be increased by rototilling a portion of the stored topsoil into the upper subsoil layer before spreading the remaining topsoil. A soil test of this sub-layer will determine if an application to the subsoil of fertilizer or other soil amendments is needed to encourage root growth. Plants with deep and extensive root systems are much more likely to survive periods of drought than will those with shallow roots. After the final topsoil layer is spread, another soil test should be conducted to determine if any amendments such as nutrients or organic matter are needed before the area is seeded or planted.

Site Assessment for Existing Managed Landscapes

Assessment of an existing managed landscape may be made to identify and correct problem areas when considering renovations, or before changing management practices. Site assessment for existing managed landscapes starts by identifying the conditions listed above with the addition of the following.

- an as-built landscape plan showing the location of structures, various planting types, underground utilities, the irrigation system, and other land uses;
- the condition of the existing irrigation system and drainage patterns;
- a history or summary of recent fertility management and soil amendments used; especially those that may contain nutrients or alter pH;
- a list of current or potential problem areas; and
- a list of client/owner requirements and expectations.

The planning and construction protocols outlined above for new construction should be followed to the extent possible.

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Section 4

Soil Nutrient Analysis: The Importance of the Soil Test

- **Regular soil tests are a necessary component of any turf or ornamental planting management program that includes fertilization or the addition of soil amendments.**
- **A soil test provides the following information: soil pH; the amounts of plant nutrients present; soil texture and organic matter content: cation exchange capacity; and recommendations for fertilization, pH adjustment, and soil amendments.**
- **A soil test should be conducted as far in advance of new landscape installations as possible.**
- **For established plantings, a complete soil test should be conducted every three years and soil pH should be determined annually.**
- **This section provides detailed instructions on collecting soil for a soil test.**
- **A sample soil test is provided along with detailed instructions for interpreting the test results and guidelines to correct the identified deficiencies.**

In this section, we look at a few basics about soil and then discuss the importance of soil testing. An example of a soil test is presented and analyzed.

Soil

The upper-most layer of the earth's crust is referred to as soil. Subject to continual weathering and human management, soil is a mixture of mineral matter, derived from underlying rock, organic matter both living and dead, and air and water in the pore spaces. Soil particles are described as sand, silt, and clay in descending order of size. The particle size distribution in any particular soil determines its texture. If the soil is almost exclusively comprised of sand-sized particles it is called "a sand" or "a sandy soil." Coarse particles, such as sand, do not retain water well and are, therefore, a poor base for plantings. They are also a poor support for plant roots. If there is a distribution of sizes consistent with good plant growth (approximately 40 percent sand, 40 percent silt, and 20 percent clay), then the textural name is loam. The fine materials in a loam hold more water than sands. When the mixture of particle sizes consists of more sand and less silt it is defined as a sandy loam. The organic matter in soil is derived from plants, micro-organisms, and insect and animal residues. Soil organic matter increases soil-moisture retention capacity. A sandy loam, rich in organic matter, is an ideal soil for supporting plant life. A well-structured loam promotes air and water movement throughout the root zone, influencing optimum growth. Soil structure is influenced by seasonal expansion and contraction due to freeze-thaw and wet-dry cycles. A predominantly sandy soil shows very little evidence of structure.

Nantucket's Soil

Nantucket was created during the maximum extent of the Wisconsin-age ice sheet some 12 to 18 thousand years ago. The slowly flowing glaciers moved material from roughly north and west of Boston toward the sea. The source rocks were granite and granite like, which geologists call acidic igneous rocks. In their movement, the fragments of rock were ground into sand-sized particles and, in the case of glacial flour, clay-sized ones. Where the ice stopped moving forward, a band of material was left at its base, which is now called an "end" or terminal moraine. This band, on Nantucket, forms the mid-Island ridge that extends from the Cliff on the north shore to Sankaty Head on the eastern shore. The moraine and material to its north is comprised of coarse particles including small boulder-sized rocks called cobble. Cobble can be seen on the harbor shore at the University of Massachusetts Field Station. To the south of the moraine is the outwash plain formed by flowing melt water that carried sand and silt particles southward. Deposits of fine, flour-like material also were blown off the glacier and settled to form relatively impermeable clay layers which can be found scattered across the island.

A typical Nantucket soil tends to be sandy and acidic. It is deficient in nitrogen, in some instances rich in phosphorus, often mildly deficient in potassium, and with the exception of mucky peats characterizing some wetlands, deficient in organic matter. To become productive for turf, crops or gardens, varying degrees of human management are necessary to amend soil with the addition of organic matter, lime and fertilizers. A soil test will determine precise characteristics of soil, and recommend fertilizer and amendment amounts for building healthy soils for manmade landscapes.

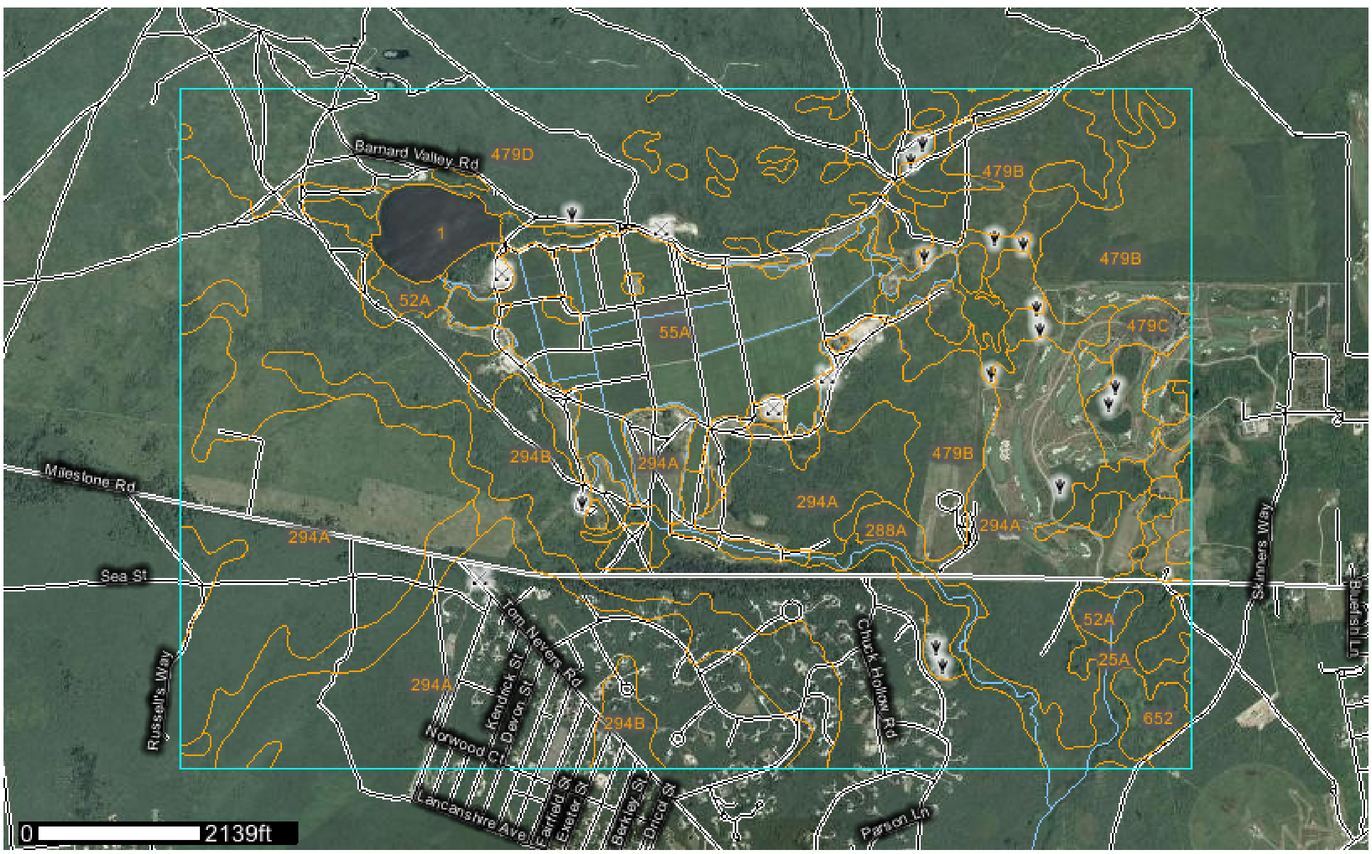


Figure 1. A soil map of the lands around Milestone Cranberry Bog, Nantucket (USDA, Natural Resources Conservation Service, Web Soil Survey); detailed legend and reference may be found in Appendix 1.

Soils with similar characteristics are given a type name; soil maps show the areal extent of soil types. Figure 1. is a soil map of a portion of the Nantucket moors and the

Milestone Cranberry Bog (www.websoilsurvey.nrcs.usda.gov). The numbers in the figure refer to individual soil types; the complete map and legend is found in Appendix 1. The Web Soil Survey can also produce agronomic and engineering characteristics for each named soil type. Using the Web Soil Survey, a person can find the soil map of any individual plot of land along with its characteristics.

Nantucket's natural soils are predominantly sandy, very low in organic matter content, and thus vulnerable to fertilizer leaching when fertilizers are applied incorrectly. Most lawns, gardens, and manmade landscapes are dependent on varying degrees of alteration to natural ecosystems to grow and thrive. Increasing soil fertility through seasonal fertilizer applications is a fundamental way in which we build healthy and successful lawns and gardens. Knowledge derived from soil testing is recommended to ensure science-based nutrient management decisions. An agronomic soil test, of the sort that is recommended throughout this BMP, is a shortened form of the soil analysis found in the Web Soil Survey. The soil test, as performed on lawns and gardens, uses physical soil samples, taken from the lawn in question, that are laboratory tested and has, therefore, information specific to the tested lawn or garden.

Proper soil fertility for turf and landscape plants includes an ideal balance of minerals, nutrients, and organic matter. Building the soil with organic matter to appropriate levels and choosing correct fertilizers to maintain plant growth and vigor must be based on a thorough understanding of the soil of a particular site. A soil-test analysis from a reputable laboratory is the key not only to assessing your soil but is also a starting point for decisions on how to amend or enhance it for optimal turf and plant growth.

The chemical and physical characteristics of a particular soil are obtained with a soil test. Chemical analysis provides information on nutrients, heavy metals, salinity, pH, buffer pH, and Cation Exchange Capacity (CEC). Physical analysis evaluates texture and percent organic matter. Recommendations for corrective measures, specified for a defined crop (turfgrass is a crop in this case), are included with the soil analysis. Following the soil-test recommendations as modified for Nantucket is an important way to ensure that lawns and gardens are being fertilized correctly.

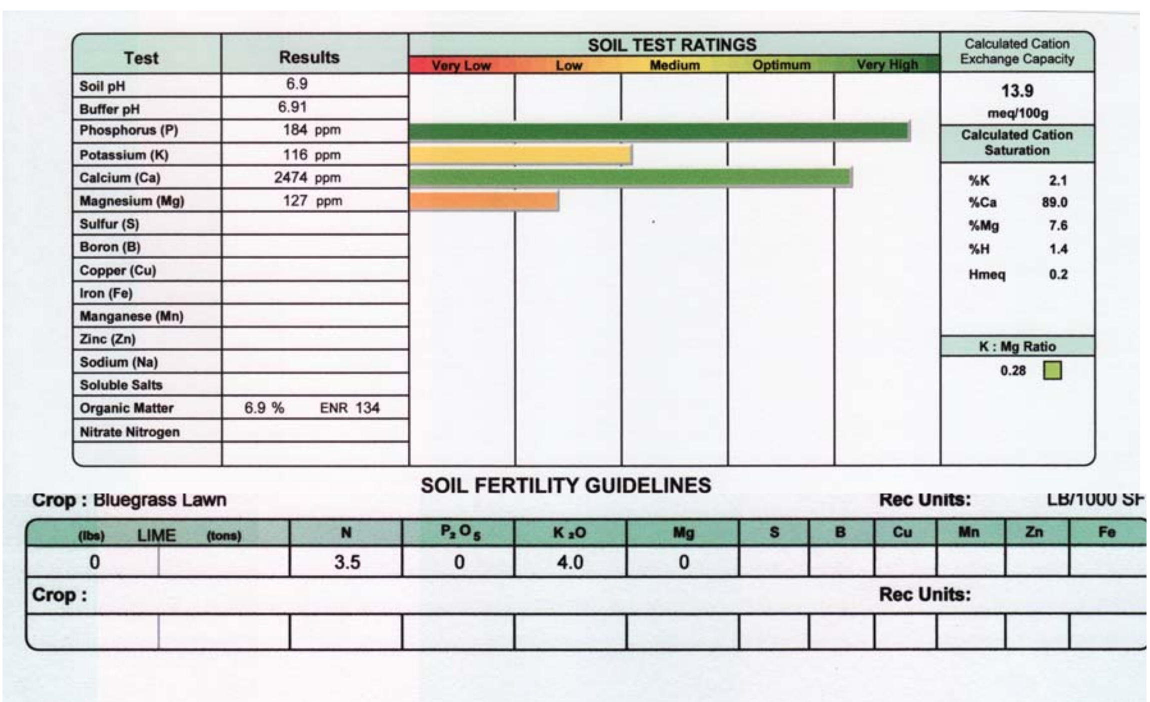
For soils in established, healthy turf or gardens, a comprehensive soil test is recommended every three to four years, or more often if there are problems that require correction. Turf pH should be monitored annually. Both acid and alkaline conditions can affect nutrient availability, especially in turf. For a new landscape installation, the soil being used should be tested as far in advance as possible to allow enough time for any recommended adjustments to the soil pH, texture, organic matter, or nutrient levels to become effective.

Collecting a Proper Soil Sample

Accurate results and recommendations from a soil-test lab depend on obtaining a good sample. Individual labs provide detailed instructions on collecting, labeling and sending samples. Links are provided to two recommended labs: http://www.al-labs.com/, A&L Laboratories; and http://www.umass.edu/soiltest/, UMass Soil Testing; both provide comprehensive soil-testing instructions. For further lab contact information refer to Appendix 3.

Some tips for obtaining good soil samples follow.

- Use a stainless steel or chrome-plated soil probe, auger or trowel. Do not use brass, bronze, or galvanized tools because they may contaminate samples.
- Numerous samples of a representative area should be taken to a depth of 4” and mixed together. Place 1- 2 cups of the mixed sample into a quart-size sealable plastic bag, and label it with property identification and type of use.
- Each sample should represent one use area: e.g., a lawn, a vegetable garden, or a perennial garden.
- Samples can be taken any time of year but, for consistency, should be at about the same time of the year in successive years. If done at the end of the calendar year, laboratory results will be returned in time for the next growing season.
- For recently limed or fertilized soil, testing should be delayed by eight weeks to allow time for the nutrients to become available.
- Take separate samples for areas showing abnormal plant growth, discoloration or other cultural problems, and for areas that have markedly different soil types.



Test	Results
Soil pH	6.9
Buffer pH	6.91
Phosphorus (P)	184 ppm
Potassium (K)	116 ppm
Calcium (Ca)	2474 ppm
Magnesium (Mg)	127 ppm
Sulfur (S)	
Boron (B)	
Copper (Cu)	
Iron (Fe)	
Manganese (Mn)	
Zinc (Zn)	
Sodium (Na)	
Soluble Salts	
Organic Matter	6.9 % ENR 134
Nitrate Nitrogen	

SOIL TEST RATINGS: Very Low, Low, Medium, Optimum, Very High

Calculated Cation Exchange Capacity: 13.9 meq/100g

Calculated Cation Saturation	
%K	2.1
%Ca	89.0
%Mg	7.6
%H	1.4
Hmeq	0.2

K : Mg Ratio: 0.28

SOIL FERTILITY GUIDELINES

Crop : Bluegrass Lawn   Rec Units: LB/1000 SF

LIME (lbs)	LIME (tons)	N	P_2O_5	K_2O	Mg	S	B	Cu	Mn	Zn	Fe
0		3.5	0	4.0	0						

Crop :   Rec Units:

Figure 2. A Sample Soil-Test Analysis for a Nantucket soil. This is an actual soil but is not representative of all Nantucket soils.

Explanation of the Sample Soil Test Analysis

In this sub-section, each of the components of the soil test is presented along with probable ranges for the units by which the component is measured. The information in this section comes from an accredited laboratory; further explanation can be found in the reference works listed in the bibliography.

Soil Test Ratings: Individual nutrient elements from this lab are rated with five levels: from "Very Low" to "Very High." "Very Low" means the soil is deficient and the addition of the element is beneficial for the crop tested in this sample, which is a bluegrass lawn. A "Low" or a "Medium" level means that a specified amount of the nutrient needs to be added to the soil to maintain correct fertility. "Optimum" means the correct amount of nutrient is present in the soil and it does not need to be added. A "Very High" level means the nutrient is present in the soil in excess of what the plant needs. The BMP is concerned that excesses can lead to nutrient losses into ground and surface water.

Soil pH: pH, which stands for "parts of Hydrogen," measures soil acidity or alkalinity. A pH of 7.0 is neutral. Values higher are alkaline while values lower are acid. A pH of 6.0-7.0 is the desired range for most turf and garden plants grown in mineral soils. Correct soil pH is important for the plant's ability to absorb and utilize fertilizers. This soil test indicates that pH is in the optimum level for a bluegrass lawn.

Phosphorus: Elevated levels of phosphorus are a major contributing factor to freshwater-pond contamination. This test measures phosphorus that is readily available to plants. 40 to 100 parts per million, PPM, is adequate for most lawn and garden plants. In this sample, phosphorus measured "Very High"; so none should be added.

Potassium: This test measures available potassium in a soil. The optimum level will vary with plant, yield and soil type. A potassium level of 120-200 PPM is adequate for most plants. If deficient, higher levels are generally needed on soils high in clay or organic matter versus soils that are sandy and low in organic matter. As mentioned in Section 2., there are two different tests that can be used to measure phosphorus. When comparing results, care should be taken to use the same test.

Calcium and magnesium: Calcium deficiencies are rare when the soil pH is adequate. Magnesium deficiencies are more common. Calcium will be in the optimum range once lime is applied to adjust to the pH-level appropriate for the chosen plants. Apply dolomitic lime if magnesium levels fall below 70 PPM.

Sulfur: This test shows no ratings for sulfate sulfur, the readily available form of sulfur preferred by plants. Optimum levels usually range from 20 to 30 PPM.

Micronutrients (zinc, manganese, iron, copper, boron): Turf grasses need very little amounts of these micronutrients and soil can usually provide enough when the pH is below 7.0. For garden and flowering plants, the optimum range for zinc is 6-10 PPM, manganese is 20-40 PPM, iron is 10-50 PPM, copper is 0.4-5.0 PPM, and boron is 0.8-

2.0 PPM. These levels may be somewhat arbitrary, as there are no scientific studies to confirm these levels for turfgrass health or uses.

Sodium: Sodium is a non-essential nutrient for most crops. Its effect on the physical condition of the soil is of greater importance. High sodium levels may cause adverse physical and chemical conditions in soils. Excessive levels of sodium can be reduced by leaching and through the application of calcium sulfate (gypsum).

Soluble Salts: Excessive concentrations of various salts can develop in soils. This may be from natural causes, the result of irrigation with high salt-content water, excessive synthetic fertilizers, and organic composts, or contamination from chemical or industrial waste. Above 1900 PPM is hazardous and needs to be leached from the soil.

Organic Matter: Organic matter, OM, is expressed as a percentage of the total soil mass. It measures the amount of decomposed plant and animal residues in a soil. It is clear that on Nantucket the organic matter percentages are much lower than found on the mainland. Some of this may be a result of weather-stunted growth of plants in open areas but the main reason for the lower values is the rapid oxidation of carbonaceous and nitrogen-bearing material into volatile forms that are lost to the soil. This rapid decomposition is a function of Nantucket's sandy soils and is very difficult to impede. It means that the development of a soil that is at the upper end of a Nantucket spectrum (3 percent or so) may take a number of years of supplemental feeding.

ENR, next to OM in Figure 2, refers to "Estimated Nitrogen Release." This number, 134, indicates the amount of nitrogen in pounds per acre that can potentially be released from the OM content in this soil throughout the season under ideal conditions. In normal conditions, somewhat less will be released in any one year. To convert this figure to lbs. per 1000 square feet, divide by 43.56 (43,560 square feet equals one acre). After converting to lbs. per 1000 square feet, an estimated 3.08 lbs/1000sq ft of N from OM may be released over the course of the season, which is greater than the total annual need by turf on Nantucket for nitrogen. The rate at which organic matter will decompose and release nitrogen depends on many factors, but those having the greatest influence are soil type, moisture and temperature. The rate of nitrogen release will be greater in higher soil temperatures and moisture levels. In this example, with the amount of nitrogen from OM potentially available over a growing season, additional inputs may be greatly reduced. ENR is not a reliable way to assess nitrogen demands but does give a snapshot of the potentially available nitrogen in a soil.

Calculated Cation Exchange Capacity (CEC): This factor measures the soil's ability to hold elements with positive charges such as calcium, magnesium, potassium, sodium, and hydrogen. The CEC of a soil will increase with higher amounts of clay and organic matter. The normal value for loamy soil is 4-8. This test shows excellent cation exchange capacity, an important factor in nutrient availability to plants. Recent studies indicate 6 as the critical CEC level. Recent studies indicate 6 as the critical CEC level.

Applying the Soil Test Fertility Guidelines to Correct Deficiencies

Soil fertility recommendations, at the bottom of the sample soil test, list recommended rates of nutrients, as pounds per 1000 square feet, to correct identified deficiencies. It is stressed that this is an example culled from the literature and is not specific to Nantucket.

Since the value of K is below optimum and Mg is in the low range, we need to add these nutrients to balance the soil. The fertility guidelines of the soil test recommend adding 4.0 lbs K per 1000 square feet. Either an organic or a synthetic source of K may be used. When using a combination product whose application rate is determined by nitrogen needs, it may be necessary to spread additional potassium. If too much K will result from using a combination product, alternative sources must be found.

Only one pound of K can be applied efficiently per application, so the K should be applied in successive applications over the season. Four applications of sulfate of potash at 1.93 lbs per 1000 square feet, or four applications of sulfate of potash-magnesia at 1.2 lbs per 1000 square feet, should be applied throughout the growing season to bring the K level to the optimal range.

Once application rates for correcting deficiencies are determined, soil ENR, visual inspection of plants for color and vigor, and cultural practices factor into determining a seasonal fertility program for the turf.

The pH is in the optimum range of 6.0-7.0 for turf grass, so it does not require lime.

In this example, OM is 6.9 %, which results in an ENR of 3.08 lbs/1000 sq ft of N. ENR helps to give us a 'snapshot' of what level of nitrogen may be present in the soil, and what could "potentially" be available for uptake. Not all of the N contained in the soil may be available when the turf needs it, because N is extremely changeable in soil. This potentially-available nitrogen may reduce the need for additional N inputs to maintain turf performance and soil fertility. With combined cultural practices of recycling clippings, correct irrigation management, and appropriate mowing height, very little additional nitrogen may be needed to promote a healthy turf.

Section 4. Bibliography

- United States Department of Agriculture, Natural Resources Conservation Service, Web Soil Survey, http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

Section 5

Building the Soil

- **Nantucket soils are primarily sandy, with low organic matter content and poor water and nutrient-retention capacity.**
- **Compost consists of partially decomposed plant and animal material. Well-made compost includes beneficial bacteria and fungi. Plant-based composts have lower levels of phosphorus than manure-based compost.**
- **Compost can be used to increase soil organic matter, add nutrients, increase aeration, and improve soil-water and nutrient-holding capacity. Because of the large amounts of compost necessary to increase a soil's organic matter content, only plant-based compost should be used to increase OM and soil tests should be taken between applications to monitor nutrient levels.**
- **Compost provides energy for beneficial soil organisms and helps support soil microbial activity.**
- **When preparing soil for new turf or ornamental plantings, rototill compost into the soil to a depth of six to twelve inches or to the bottom of the projected root zone.**
- **Established turf can be top dressed with a ¼" of compost per application. Turf should be core aerated prior to composting and compost raked into turf. Soil should be tested before any additional applications are made.**
- **One-half to one inch of compost can be incorporated into garden beds annually to serve as a fertilizer and soil conditioner.**
- **Compost tea is a liquid diffusion of compost; though not yet scientifically supported, it is used primarily as a means of supplementing microbial activity in soil. It is also used as a foliar fertilizer.**
- **Compost and compost tea are considered to be fertilizers by this BMP. The amounts of nitrogen or phosphorus added during composting must be included in annual, application totals.**
- **Avoid compost containing significant amounts of phosphorus unless a soil test indicates a phosphorus deficiency. The compost source should be sampled annually to determine nitrogen and phosphorus content. Composts that contain high levels of soluble salts, lack proper maturity, and have an improper pH, should also be avoided.**

The Role of Compost

The earlier discussion on soil suggested that a healthy soil is a sandy loam containing five or six percent organic matter. Nantucket's native soils are mostly sand and have little to no organic matter. This section discusses soil augmentation for improved growth, primarily through the addition of organic matter. Soil and compost testing are extremely important when augmenting soil to avoid any nutrient over loading. Where gardens or lawns have been augmented with imported soil or turf has been established with sod, it is just as important to have a soil test that characterizes the new soil.

Increasing soil organic matter content by adding compost improves soil structure, aeration, microbiology, and the soil's water- holding capacity. Compost also provides food for microorganisms and helps to maintain soil in a balanced healthy condition. A turf or garden soil that has been amended correctly with compost can significantly lower the demand for both water and fertilizer inputs.

Compost is the end product of a complex biological process of decomposition involving hundreds of different organisms including bacteria, fungi, worms, and insects. In simplest terms, compost is decomposed organic material. Compost can be derived from both plant and animal residues. Plant-based composts are lower in nitrogen and phosphorous and tend to last longer in the soil than manure-based composts. Adding compost to soils in manmade landscapes, where nature's recycling has been removed, helps to build and maintain soil-fertility levels for turf and gardens. Compost is commercially produced and available in bulk or bags for the landscape trade. Commercially available composts, particularly when packaged in bags, may be labeled with a good content analysis. Most bulk compost suppliers should provide an analysis of their product as well. These analyses should be referenced with a soil test prior to using the product. Compost may also be generated at home with garden waste products including grass cuttings and swept-up leaves. Home-produced composts should be tested to determine their nutrient content.

In terms of its nutrient content, compost is a fertilizer and contains varying amounts of nitrogen, phosphorus, and potassium depending on its source. Plant-based compost will be low in phosphorus (P_2O_5), 0.1 to 0.2 percent, and moderate in nitrogen; cow manure will be higher in nitrogen and have a phosphorus content of 0.8 to 1.2 percent; chicken manure will also have an adequate amount of nitrogen but, often, too high of an amount of phosphorus for typical Nantucket soils, 1.8 to 2.0 percent. Some manure-based composts, particularly from poultry, will have elevated amounts of salt in them and this must be checked before applying them.

Concern exists for the amount of compost to be added to a soil for amending its content of organic matter because it is easily possible to add too much nitrogen or phosphorus while doing so and these are the very elements that need to be limited to protect waters. The amount of these nutrients in compost must be known and be factored in to nutrient management planning for turf or gardens. A conservative approach to the use of compost is to apply less rather than more and then take a soil sample eight weeks later. The analysis of that sample can guide subsequent applications of compost.

Organic Matter (OM) Soil Content

The normal ideal range for organic matter (OM) content in soils for turf and gardens is 5-8 percent. Because of the increased volatilization by weathering of organic sources of carbon and nitrogen in dry, sandy soils such as exist on Nantucket, the ideal range is somewhat less here. For Nantucket, the ideal is considered to approach 3 percent. In actuality, Nantucket's naturally sandy topsoil contains OM in ranges as low as between 0.8 -2.2 percent. Compost is one of the best products for increasing soil OM content. Other products commonly used on Nantucket to increase soil OM are horse and chicken manures. It is important that these manures be composted properly before being applied or incorporated into soil, because when used in raw form, they may damage plants or contribute to nutrient leaching. It has been noted that poultry manures can be high in sodium, which, because of its toxicity to plants, becomes the limiting factor in application rates.

As soil organic matter decays, some of its carbon and nitrogen is released to the soil and atmosphere. In addition, growing plants take up nutrients. In a situation of equilibrium growth, newly fallen vegetation replaces these losses and plant populations are constrained by the availability or lack thereof of nutrients. Where grass clippings and fallen leaves are removed as part of lawn maintenance, the organic matter content of a soil could fall below this equilibrium level and fertilization is needed or the plant populations will decline. In lawns where organic matter levels are elevated, such as when clippings are allowed to remain on a lawn, the reserve of organic matter could remain at its optimum level. There are many examples on Nantucket of mature lawn plantings that require little to no extra fertilization to remain green and healthy throughout the growing season.

On the other hand, if a newly established lawn or garden is found to be deficient in organic matter, then the addition of compost can remedy this situation over time. As explained in the next section, additions of reasonable amounts of compost may be preferred to attempting to do it all in one application. The challenge is two-fold: new plantings may not have a sufficient root system to provide a host for large quantities of organic matter and large doses of compost may overload the soil system with nutrients, particularly phosphorus, where the excess amounts are able to leach into groundwater. Annual soil tests and regular examination of the health of the turf or garden plants will indicate if correct amounts have been applied.

Applying Compost

To amend soil for the establishment of new turf, compost should be mixed into the soil prior to seeding, which is easily accomplished using a rototiller. Layering compost into the soil without mixing not only impedes water and air movement, but can provide for a 'band' of nutrients that are more likely to leach. Compost can be added to existing turf by topdressing. When topdressing, a lawn should be core aerated first to prevent layering and then topped with ¼" of compost with the exact amount being dependent on the source of the compost. This amount of compost can be applied late spring or early fall. It is important to note that adjustments to organic matter content should be done over time, often 10 to 25 years, to prevent the application of excess amounts of nutrients.

Section 8. "Fertilizer Application Timing and Rate Guidelines," provides guidance on amounts and schedules for applying fertilizer. Inasmuch as compost is a fertilizer, there is a table in this section that suggests amounts of compost to be applied for desired nitrogen outcomes. It is stressed that this table is based on assumptions, the biggest of which is the amount of nitrogen to be derived from the compost in a year, and that it gives approximate guidance only.

An application of one-half to one-inch of compost, incorporated annually to perennial or mixed gardens, ornamental shrubs, and trees, can act as a fertilizer and a soil builder. In this BMP, compost is considered a fertilizer because it contains varying amounts of nitrogen, phosphorus, and potassium. Before applying or incorporating compost into soil, it is important to ascertain its nutrient content to factor in when determining application rates.

Critical to the assessment of application amounts of compost is the soil's phosphorus level. If a soil test indicates a deficiency in phosphorus, then compost may be added as noted above. When considering how much phosphorus may be added, one should note the nature of the test that was used and then follow guidance for that particular test (Mehlich III or Morgan) on how much additional phosphorus is needed. If the phosphorus level is optimum for plant growth, small amounts of compost may still be added to soil but that compost must be a low phosphorous and a soil test should follow before any additional applications are made.

Compost is available in bags and in bulk. Bulk compost must come from a reliable source and have a lab-certified content analysis, similar to soil analysis. Small-scale composting can be especially useful for home gardeners. Testing should be performed annually to have a thorough understanding of the nutrient content, especially nitrogen and phosphorus, of the compost applied. For more information on other sources of organic matter, compost, compost tea, and composting, refer to the bibliography.

Compost Tea

Compost tea is an amendment that may add beneficial microorganisms to soil or leaf surfaces. It is made by steeping well-aged compost in oxygenated water. The process involves adding a variety of nutrients and supplements and takes several days. Organisms and nutrients created in compost tea can vary widely depending on how the tea is made. It is important to test compost tea before using it as the addition of nutrients and supplements can enhance the growth of human pathogenic bacteria, in addition to those bacteria and fungi that are beneficial to soil health. Consequently, take extra care when applying composts derived from manures Compost tea needs to be filtered and used as soon as possible as the organisms die rapidly if not kept aerated. For more information on compost tea see "Compost Tea: Easy As 1, 2, 3" in the following link from the Pennsylvania Department of Environmental Resources, who maintain a content-rich web site:
http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/Tea/tea1.htm .

Conclusion

For purposes of this BMP, compost is considered a fertilizer. As with all landscape nutrient-management programs, understanding how nutrients, whether organic or synthetic in origin, move through the soil and are made available to plants is the basis for determining correct rates and timing of all fertilizers. Section 6. "Fertilizer Types and Sources" and its associated appendix include comprehensive descriptions of all sources of nitrogen (N), phosphorus (P), and potassium (K).

For more information on building the soil, organic landscape management, compost, and compost tea, please refer to the bibliography.

Section 5. Bibliography

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Section 6

Fertilizer Types and Sources

- **Fertilizer is a generic term for a material that contains one or more plant mineral nutrients. Fertilizers may also contain microbial agents.**
- **Nitrogen (N), phosphorus (P), and potassium (K) are the primary nutrients found in fertilizers.**
- **This section discusses the similarities and differences between organic and synthetic fertilizers and between slow, or controlled, release (water insoluble, for the most part) and fast release (water soluble) nitrogen fertilizers.**
- **Numerous, commonly used natural and synthetic sources and types of nitrogen, phosphorus and potassium fertilizer are discussed in an appendix, along with guidelines for their use on Nantucket.**
- **Instructions on how to read and interpret fertilizer labels are presented.**

The sources and types of fertilizers available today are numerous and vary widely. Blends are formulated and specified for everything from turf, to roses, hollies and hydrangeas. The terms organic or natural are often included on fertilizer labels and can be misleading. More important to understand, when choosing which fertilizer to apply for plants growing in Nantucket's climate and soils, are the specific forms of the three macronutrients: nitrogen (N) , phosphorus (P as P_2O_5), and potassium (K as K_2O) found in a typical fertilizer. Fast release, slow release, water soluble, or water insoluble are all terms that more accurately describe how and when nutrients applied will be available to turf and plants. This section explains sources of types of fertilizers in detail. As always, before applying any fertilizer, whether to turf or garden plants, a soil test is recommended to ascertain what nutrients may be deficient or already available in the soil.

Interpreting Nutrient Ratios on a Typical Label

The nutrient ratio on a fertilizer bag is easily misunderstood. Fertilizer analysis, as stated on the label on the bag, is the legal guarantee of the percentage of elemental N, nitrogen, percentage of P_2O_5, a source of phosphorus, and the percentage of K_2O, a source of potassium contained in the product. Fertilizer ratio is the ratio of each ingredient to the others. In the sample label below, the fertilizer analysis is 8-4-8. The amount of nitrogen is expressed on an elemental basis (actual nitrogen), whereas phosphorus is expressed as available phosphate (P_2O_5), and potassium is expressed as potash (K_2O). The label indicates that 8 percent of the product's weight is total nitrogen, 4 percent is available phosphate, and 8 percent is potash. The ratio of these three, expressed in the lowest common denominator, is 2:1:2. The label will describe from what sources the fertilizer was derived as well as what percentage of nitrogen (N) is slow release. Information about slow-release nitrogen is explained in greater detail below.

Figure 3. A Sample Fertilizer Label Analysis

Some fertilizers also provide information on micronutrients and non-plant food ingredient content and the amounts and types of beneficial microbes in the product as indicated in the label below.

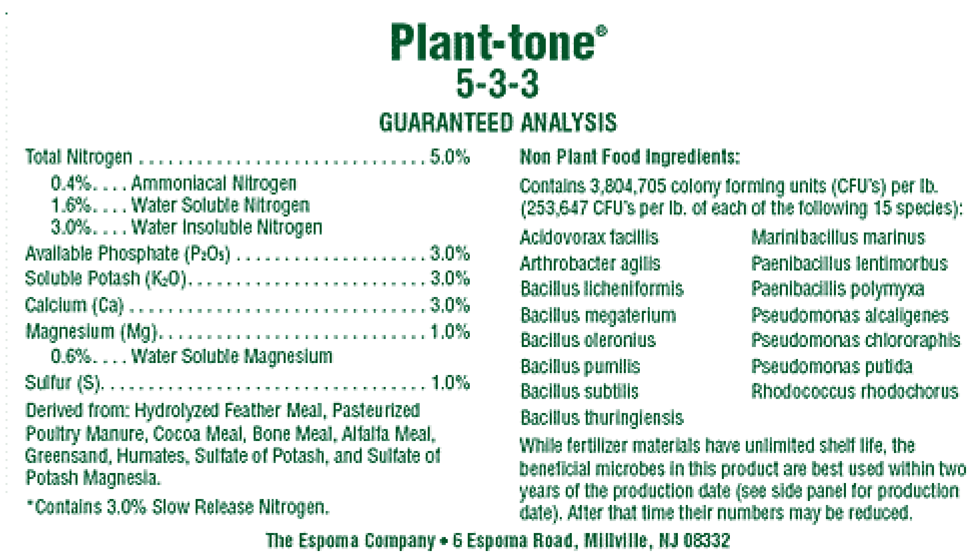

Figure 4. A Fertilizer Label including Non-Plant Food Ingredients.

When determining the proper analysis, or blend of nutrients, with which to fertilize, a soil test should always be followed. A soil test will reveal the need for macronutrients such as phosphorus and potassium, secondary nutrients such as calcium and magnesium, and finally micronutrients such as iron and manganese. A reputable soil-testing laboratory will also provide recommended rates to use. Contact information for two laboratories is included in the appendix. Soil tests are discussed in detail in Section 4. "Soil Nutrient Analysis: The Importance of the Soil Test."

The majority of soils on Nantucket may have adequate, or even high, levels of phosphorus and may not require phosphorus fertilization. A fertilizer containing phosphorus should only be applied after a soil test has been conducted showing a phosphorus deficiency. Only the amount recommended to correct the phosphorus deficiency should be applied. Potassium is vital for plant growth, and while not a constituent of any part of the plant, does aid in carbohydrate movement and helps open and close stomata for water use efficiency.

When referring to a soil test for these nutrients, if a deficiency is found, a recommended rate will be given to correct the deficiency. The rate will be stated as pounds of phosphate (P_2O_5) per 1,000 square feet in the case of phosphorus and pounds of potash (K_2O) per 1,000 square feet in the case of potassium.

Before undertaking a more in-depth discussion of nitrogen sources, it might be useful to define the following abbreviations commonly used in describing the nitrogen portion of the fertilizer analysis or ratio.

- <u>WIN</u> – Water insoluble nitrogen. Nitrogen in this form will not break down by hydrolysis (water) rapidly, but instead is reliant on microbial activity and soil temperature for its release. WIN can be a very good indication of how slowly nitrogen will release and become available to the plant except for coated fertilizers (see CRN below). Typically, the higher the amount of WIN in a fertilizer, the more slow release is the product. WIN is listed by percentage on the label of the fertilizer bag. It should be noted that WIN nitrogen is released eventually into the soil and, if more is applied than is needed by the plants, can contribute to nutrient contamination just as the water-soluble nitrogen listed below.

- <u>WSN</u> – Water-soluble nitrogen. Nitrogen in this form is released by rain, irrigation, or water in the soil. Generally, WSN is immediately and quickly available to the plant, although some WSN products are protected by a physical barrier that make them slowly available. In this case, the term slowly available water soluble nitrogen (SAWSN) applies. WSN is usually listed by percentage on the label of the fertilizer bag. A subsequent section talks about the challenge of a large rain event or excessive irrigation falling just after the application of water-soluble nitrogen.

- <u>SRN</u> – Slow-release nitrogen or slowly available nitrogen. This term encompasses many types of nitrogen sources that are designed to release over time. SRN can be organic, synthetic, or in a 'bridge' product, which is a combination of organic and synthetic. The amount of time for nitrogen to release is dependent on the source or chemistry of the individual product. SRN can contain WIN and CRN (controlled or coated slow release nitrogen) sources.

- CRN – Initials for controlled or coated slow-release technology; another form of slow-release nitrogen. Usually CRN fertilizers are synthetic and the slow-release percentages can range from 25-100 percent.

Most fertilizers contain a blend of WIN, WSN, and SRN. Others are 100 percent WSN or 100 percent WIN or SRN. Products that are 100 percent WSN, such as a straight 46-0-0 urea or potassium nitrate should be carefully diluted to meet the 0.25 lb per 1000 sq ft limit discussed later, be part of a strict spoon-feeding fertilizer program, or be avoided altogether on Nantucket. If they are part of a blend, they must conform to the requirements in Section 8. "Fertilizer Application Timing and rate Guidelines" in regard to the minimum amount of slow-release nitrogen required.

Sources and Types of Nitrogen Fertilizers

Sources of nitrogen in a bag of fertilizer can vary greatly. The type of fertilizer – slow release, quick release, natural organic, blended product, synthetic slow release, etc. – varies just as much. However, when broken down to its most basic level, nitrogen is either fast release or slow release. Fast-release types of nitrogen are soluble in water and are rapidly available to the plant after fertilization. Because of their high solubility in water, leaching can be a concern for some fast-release sources particularly if applied in or just before a large precipitation event. Conversely, because of the potential build-up of reserve nitrogen in the soil, slow-release sources can also contribute to leaching

Fast-release sources of nitrogen are usually present, in at least a small percentage, in any blended fertilizer, whether organic or synthetic. However, for applications made on Nantucket, no fast-release source may exceed the rate and percentage guidelines listed in Section 8. "Fertilizer Application Timing and Rate Guidelines." A brief discussion of some synthetic fast-release nitrogen sources is listed in Appendix 4.

Slow-release nitrogen sources delay the release of nitrogen in various ways and may reduce the risk of leaching, particularly when the risk of leaching is high, such as in an abnormally wet season. Using slow-release products on Nantucket's turf and garden soils can be an important step in protecting its waters. However, slow-release nitrogen sources and products vary greatly. Many products are available and sold as slow release and some are better than others in predicting and controlling the release of nitrogen. Many types of organic and synthetic fertilizers are excellent at controlling the release of nitrogen. But it is imperative to read the label to determine the percentage of slow release nitrogen for either organic or synthetic products. On Nantucket, the percentage of slow release N applied to turf or soil must be no less than 50 percent as explained in Section 8. Only the following exceptions are made:

- Foliar fertilizer applications at less than 0.25 lbs. of actual nitrogen per 1,000 sq.ft. Foliar feeding is discussed in greater detail in Section 8.
- Spoon feeding with fast-release products at 0.25 lb/1000 sq ft of N or less.

Nitrogen release from slow-release fertilizers is not monotonic, i.e. at a steady and predictable rate, but is a factor of temperature, soil moisture, and microbiotic activity and can vary with fluctuations in these factors. A slow-release fertilizer is ideal when rainfalls are unpredictable but sudden; the nitrogen is not lost in a sudden rush as might be the case with a fast-release fertilizer. On the other hand, in normal moisture conditions, i.e. drier, the use of slow-release fertilizers is no protection from the losses that come from excessive application.

Sources and Types of Phosphorus Fertilizers

If after conducting a soil test, it is determined that phosphorus is deficient in the soil, choosing a source of phosphorus is the next step. Because the majority of phosphorus sources contain nitrogen as well, it is necessary to account for any nitrogen applied when using these types of products. Any nitrogen applied counts against the maximum yearly use rate, and the sources of nitrogen are also subject to maximum quick release amounts as detailed in Section 8.

Sources and Types of Potassium

Though potassium is not a major focus of the Nantucket BMP as are nitrogen and phosphorus, its use and application still needs to be made responsibly and in accordance with soil-test results. Many sources of potassium have been discussed above under nitrogen and phosphorus sources, but the appendix lists (Appendix 3.C.) a few more.

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Section 7

Turfgrass Blends, Mixes, and Their Selection

- **Numerous species, varieties and cultivars of turfgrass are available for use on Nantucket. Species commonly used on Nantucket lawns include Kentucky bluegrass, perennial ryegrass, tall fescue, and several species of fine fescue. Details are placed in an appendix.**
- **This section discusses the advantages and disadvantages of the various turfgrass species, cultivars, mixes, and blends as well as appropriate uses and fertilizer requirements**
- **Species and cultivar selection depend upon intended use, soil and other environmental conditions, and degree of intended maintenance. A mix of species or a blend of cultivars may be preferable for many uses.**
- **A mix of fine fescue species is recommended for low-maintenance lawns requiring reduced water and fertilizer inputs.**
- **New varieties of turf-type tall fescues are recommended for medium to high maintenance lawns requiring irrigation and greater fertilizer inputs.**
- **Native and other warm-season grasses make a viable alternative for low-maintenance lawns.**

Turf seed mixes consist of two or more different species of grasses. A typical mix, for Nantucket's climate, contains Kentucky bluegrass, perennial ryegrass, and fine fescues. A mix of these species is fairly adaptable to differing site conditions. A blend, as compared to a mix, is made up of two or more cultivars of the same species of grass. For example, a blend of perennial ryegrass might be made up of three or more varieties or cultivars of perennial ryegrass. Blends are often used in highly-maintained lawns where uniform appearance and performance are required or for over-seeding established lawns. For either blends or mixes, at least three cultivars or varieties should be included to minimize the loss of turf when one variety or cultivar succumbs to disease or weather stress. A seed mix and a seed blend for different types of lawns on Nantucket are recommended at the end of this section.

Turfgrass selection is determined by environmental conditions, intended use of the turf area, and degree of management desired for the turf. Intended uses range from those needing very high maintenance, such as golf courses, parks, athletic fields and some residential lawns, to low maintenance uses, including situations with reduced inputs including fertilizer and irrigation, such as roadsides, sensitive areas adjacent to wetlands, and including some residential lawns. Ultimately the selection of turfgrass is a decision between the homeowner, or customer, and the landscape professional providing a range of available options.

Grasses vary in tolerance of soil moisture, pH, fertility and temperature ranges. They also vary in resistance to stresses caused by excessive wear, mowing, insects and disease. On Nantucket many species of turfgrasses can be used in mixtures to produce a dense lawn. The principal species of cool season grasses for turf are Kentucky bluegrass, perennial ryegrass, tall fescues, and fine fescues (creeping, red chewings, and hard). Cultivars within each species offer further options for improved aesthetic and resistance qualities.

The depth of turfgrass roots is highly dependent upon soil type, temperature, and moisture. In hot and dry summers, turfgrass root systems will become shallower. Some grasses are more tolerant of drought and heat than others.

Certain cultivars of perennial ryegrass, tall fescue, and fine fescues also contain fungal endophytes. Endophytes are forms of fungus living inside grasses that enhance turf quality, but are not visible on the grass. Endophytic grasses have a high tolerance of environmental stresses and may perform well under low maintenance programs. Endophytic grasses also have increased resistance to leaf feeding insects such as billbugs, sod webworm, and chinch bugs. Some cultivars of fine fescues containing endophytes also resist dollar spot, a disease associated with low fertility. Because the fungi are not compatible with animals, endophytic cultivars should never be planted where animals might graze. A thorough listing of varieties and cultivars is included in Appendix 5.

Turfgrass Mix and Blend Recommendations for Nantucket

A Seed-Blend Recommendation for Lower-Maintenance Lawns Requiring Reduced Inputs. For a low-maintenance, non irrigated lawn on Nantucket, an endophytically enhanced mix of fine fescues is recommended. These fine-fescue mixes require little to no nutrient inputs, and perform well with minimal cultural practices. Fine fescues have the potential for deep root systems, use water extremely efficiently, and can naturally avoid dormancy through all but the driest parts of the season. Fine fescues should only be watered during hot, droughty periods, and not more than twice a week; actual timing of watering depends upon turf density, soil type, temperature, etc. Watering fine fescues other than at times of heat and drought can be detrimental. Fine fescues should be mown at a minimum height of 2.5 inches. During establishment, fine fescues may be mixed with a small percentage of perennial rye grass to provide quick cover and erosion control while the fine fescues become established. If properly managed, the rye grass may die out over time; even if it does not, it is of little consequence.

A Seed Blend Recommendation for a Medium- to High-Maintenance Irrigated Lawn. For an irrigated high quality lawn, whether organically or synthetically fertilized, relatively new varieties of turf-type tall fescues are recommended for a dense dark green lawn. Turf-type tall fescues are very similar in color to Kentucky bluegrass but the leaf is just slightly coarser in texture. It takes a trained eye to tell the two types apart, and it has become more readily available in sod form in recent years. Turf-type tall fescues have the potential to develop deep root systems, allowing more efficient use of both water and nutrients. Turf-type tall fescue requires 2-3 lbs. N/1000 sq.ft. annually to maintain density. Irrigation might only be necessary for turf-type tall fescues to avoid mid summer dormancy, but irrigation should be used sparingly unless it becomes visually apparent that it is necessary. During a typical Nantucket growing season, irrigation should not be necessary until the end of June or early July depending on precipitation. At this time, if conditions are droughty, only one inch of water per week should be required, applied twice a week. Watering should be monitored to assure recharge into the root zone. As temperatures begin to cool in early September irrigation should no longer be necessary. Good cultural practices are important to maintain tall fescue performance. Annual over seeding in late summer is recommended to maintain density. Turf-type tall fescue looks best when used as a blend rather than a mixture, that is, a blend of tall fescue varieties or cultivars, not mixed with Kentucky bluegrass or perennial ryegrass.

Native and Warm-Season Grasses. Most Nantucket native grasses are varieties of warm-season grasses. While presenting some increased difficulty in establishment, once mature, warm-season grasses grow with little to no maintenance and survive droughty periods almost effortlessly. These species are a good choice for open land, property-boundary breaks, and low-maintenance lawns. Much more information about them can be found in Section 13. “Alternative naturalistic Style Practices.”

Source Material.

This section was written by Nantucket Landscapers led by Jonathan Wisentaner. It was reviewed carefully by the external reviewers credited in the Acknowledgements section.

Section 8
Fertilizer Application Timing and Rate Guidelines

- **Safe and effective fertilizer application depends on application rate and timing.**
- **Fertilizer should only be applied on Nantucket between April 15 (tax day) and October 15 (approximately Columbus Day) and when soil temperatures are above 55^{o}F.**
- **Fertilizers should not be applied before a heavy rain. Avoid excessive irrigation following fertilizer application.**
- **Nitrogen fertilizers used on Nantucket normally should contain at least 50% slow-release nitrogen. Exceptions are made for licensed applicators that follow the Nantucket BMP guidelines.**
- **The maximum nitrogen application rate on Nantucket is 3 lb N/1000 ft^2/year.**
- **No individual application should exceed 1 lb N/1000ft^2 of which no more than 0.25 lb may be fast-release fertilizer. Implicit is the understanding that no more than six (6) applications may be made in one growing season.**
- **Individual applications should be two weeks apart, at a minimum, to allow time for the fertilizer to be taken up by plants and its impact on growth assessed. The interval needs to be lengthened if applications of more than 0.5 lbs/1000 sq ft of N are applied.**
- **Phosphorus should only be applied if a soil test indicates a deficiency.**
- **Foliar fertilizers are dilute, liquid-nutrient solutions that are applied directly to, and taken up, by plant leaves. Foliar fertilizers are often applied as part of a practice of spoon feeding. Spoon feeding is often the most efficient way to fertilize, though may not be realistic for most applicators or homeowners.**
- **These guidelines are contained in a convenient table.**

The proper timing and rate of fertilizer applications are important for many reasons. From a plant-health perspective, applying fertilizer at the wrong time, or at the wrong rate, can be detrimental. From an environmental perspective, applying fertilizer at the wrong time or rate can lead to surface runoff to harbors and ponds or leaching to ground water. As pointed out in previous sections of the BMP, Nantucket's unique climate and soil conditions are intricately related to the correct application of fertilizers. Fertilizers may not be able to be taken up efficiently by the turf and plants they are intended for in early spring and late fall on Nantucket or by dry dormant turf in the summer. This section outlines timing and rates for safe and effective fertilizer applications. As always, a soil-test analysis is recommended as the basic reference for determining the soil needs of certain nutrients such as phosphorus and potash. Organic matter content, from the soil test, and a visual inspection of turf and plants, may be used to estimate nitrogen needs.

Timing

Because of Nantucket's climate, fertilizers are best utilized by turfgrass and other plants after April 15th (tax day) and before October 15th (approximately Columbus Day). Nitrogen and phosphorus fertilizers should not be applied outside of these dates. Turfgrass and ornamental plants are not as efficient in utilizing nitrogen or phosphorus when the ground is below 55 degrees Fahrenheit in early spring and do not have enough time to take up and utilize nutrients when the growing season is coming to an end in late fall. Because of these two factors, special consideration for fertilizer application should be made at either end of the growing season. It is critical to remember that Nantucket soils may contain sufficient phosphorus for plant growth and, except when shown by a soil test to be deficient in phosphorus, it should not be applied routinely. This means that people using generally available commercial fertilizer blends and composts should check the label carefully to ensure that it does not contain phosphorus, or, at least, high levels of phosphorus. It is noted that the use of a quick-release phosphorus fertilizer in a phosphorus-deficient soil – as shown by a soil test -- may be very useful at the time of initial seeding. The quick establishment of turf is an important environmental best-management practice consideration in that it reduces phosphorus movement into water through soil erosion.

The first spring fertilizer application of the year, if needed, for turf or other ornamental plantings, should not be made until soil temperatures are above 55 degrees Fahrenheit. Soil temperatures can be measured at a four-inch depth with a simple, inexpensive soil thermometer. In the spring, when soil temperatures are lower, any type of fertilizer that is dependent on higher soil temperatures for microbial activity and breakdown of nitrogen will not be effective in making that nitrogen available to the plant. A slow-release product should be chosen that releases at least a portion of its nitrogen through slow hydrolysis, i.e. the action of water. As an alternative, using a quick-release form of nitrogen at 0.25 lb/1000 sq ft of N or less can be effective. Temperature-dependent fertilizers may be applied at this time; however, it should be understood that most of the nitrogen will not be released until soil temperatures increase. Because soil temperatures fluctuate greatly in the spring on Nantucket, from April 15th until June 15th, a turf fertilizer with a minimum of 60 percent slow-release nitrogen content is recommended.

Additional applications of fertilizer should be made only after an interval sufficient to gauge the impact of the previous application: normally no less than two weeks. Again, intervals need to be lengthened if rates of N exceed 0.5 lb/1000 sq ft in any one application. Impact is seen visually by the vigor of growth and the color of the grasses.

A second turf-fertilizer application may be made no less than two weeks or even a month later, after soil temperatures have increased. Additional applications, made with intervals of two to four weeks after the previous one, may continue throughout the summer. In droughty periods, application intervals should be extended. Between June 16th and August 31, a fertilizer with a minimum of 50 percent slow-release nitrogen content is recommended, provided that rate guidance is followed. Late summer applications of fertilizer may be made for the following reasons: a new lawn in its first season of growth, a recent renovation, or damage sustained during earlier parts of the season.

Finally, the last turf-fertilizer application should be made in late summer or early fall. This is likely the most important application of the year. The fertilizer should be applied early enough in the fall for the majority of nitrogen to be taken up and utilized by the plant, with some of the slow-release portion overwintering for use in early spring. The timing of this application coincides with temperatures having subsided from the summer heat, when most of the nitrogen can be utilized for root growth instead of shoot growth. Mid to late September is ideal. Between September 1st and October 15th, a fertilizer with a minimum of 50 percent slow-release nitrogen content must be used. No applications of nitrogen or phosphorus should be made after October 15th.

These recommendations presume that there have been normal amounts of natural precipitation, or during Nantucket's typically droughty summer months, appropriate amounts of irrigation water applied.

Application Rates

As explained previously, a soil test and a rigorous visual examination of grasses and plants are necessary to assess fertilizer needs for a particular plot of land. In particular, when deciding seasonal nitrogen application rates, a thorough understanding of existing organic matter content (OM) and whether or not clippings will be recycled should both factor into total nitrogen inputs. High levels of organic matter, or the recycling of clippings, may lower significantly the total pounds of N/1000sq ft needed per season.

The season's totals of turf fertilizer applications for lawns should not exceed 3 lbs of nitrogen per 1,000 sq ft. Returning clippings can provide 25 percent of required nitrogen per season. This practice is encouraged where possible, but must be accounted for, and would be added to each site's nitrogen total for the year. For example, if a lawn requires 3 lbs of nitrogen per 1,000 sq ft per year, and clippings are returned, the actual amount of nitrogen fertilizer applied should decrease to between 2 lbs and 2.5 lbs, dependent on the amount of organic matter in the soil, its maturity, and the overall condition of the turf.

No one application should contain more than 1.0 lb N/1000 sq ft of which no more than 0.25 lb is fast-release nitrogen although total rates of 0.5 lb/1000 sq ft of N are preferred. Fertilizers with high percentages of nitrogen may be difficult to spread at rates lower than 1.0 lb N/1000 sq ft; consequently, low-percentage fertilizers are recommended.

As turf matures, it is likely that the storage of nitrogen in the soil will reach a maximum after ten years and most certainly by 25 years of growth. At this point, the release of N from the soil may be sufficient for plant growth and little to no additional N will be needed. For this reason, soil tests remain as important for mature lawns as for new ones.

Table 1
Table of Fertilizer Application Guidance for Turf Grass

Timing	Begin fertilization after April 15th (tax day) and end by October 15th (approximately Columbus Day).
Interval	Maintain two weeks or more between applications. Lengthen

	intervals if applying more than 0.5 lb N/1000 sq ft at any one time.
Total amount	No more than 3.0 lb N/1000 sq ft and no amount of phosphorus unless need is indicated by a soil test.
Individual amount	Less than 0.5 lb N/1000 sq ft per application is preferred. No more than 1 lb N/1000 sq ft is allowed. If all 3.0 lbs are desired or needed at rates of 0.5 lb N/1000 sq ft, this implies six applications over no less than twelve weeks. If all 3.0 lbs are desired or needed at rates of 1.0 lb N/1000 sq ft, this implies three applications over no less than twelve weeks.
Fertilizer release type	During times of rapid growth and fertilizer uptake, up to 0.25 lb N/1000 sq ft, of fast-release fertilizer may be used in an application. The balance must be slow-release fertilizer or, if the rate is 0.25 lb N/1000 sq ft, no additional fertilizer.
Fertilizer source	This guidance is based on the turf's need for nitrogen and is not based on the source of the nitrogen, whether natural or synthetic.

Applying Compost as a Fertilizer

Compost, as discussed in Section 5. "Building the Soil," is an extremely useful soil amendment. It contains a variety of organic substances that can contribute to the build up of organic matter in a soil. Moreover, it provides for the recycling of organic material rather than its discard. It also contains fertilizer nutrients, unfortunately, often in higher-than-needed percentages. In this section, the application of compost is discussed in the context of its potential contribution of nutrients to the soil and, if over applied, their losses into the water regime. Compost application recommendations are made, also, in the context of the limits to organic matter percentages that are found in Nantucket's native sandy soils. These range around 2.0 – 2.5 percent and rarely exceed 3.5 percent

Table 2 is a listing of various common forms of compost and includes total amounts of nitrogen and phosphate in each. The percentages in Table 2 are used then in subsequent tables for application rates.

Table 2
Nitrogen and Phosphorus Content of Selected Composts, Percentage

Type of Compost	Percent Nitrogen, N	Percent Phosphorus as Phosphate, P_2O_5
Leaf litter	0.1%	0.05%
Horse Manure	0.5 – 1.5%	0.5 – 1.5%
Lawn & Garden, food waste	1.0 – 1.5%	1 – 1.5%
Dairy manure	1.0 – 1.5%	1 – 1.5%
Feedlot manure	1.0 – 1.5%	1 – 1.5%
Poultry manure	2%	2%

Nitrogen. Table 2 provides an estimate of the nitrogen content, in percent by weight, of various forms of compost. It is noted that leaf litter is relatively low in nitrogen, which makes it a good source of organic matter while not disturbing to any large extent the annual nitrogen application from fertilizer. Animal manures are relatively high in nitrogen and calculations of nitrogen application rates must include the contribution from their use. Poultry manure is also high in sodium and may be inimical to plant growth.

Nitrogen is released as compost decomposes with some of the nitrogen made available for plant growth. The amount of N released is dependent on the compost application rate and the percent of nitrogen in the compost. A general rule is that between 10 and 25 percent of the N in compost is released on an annual basis, though this amount varies with soil temperature, precipitation, and bacterial activity.

Table 3, below, provides an estimate of the total amount of nitrogen contained in different forms of compost for varying application rates of the compost. The cells with a highlight represent applications that provide 0.5 lb or less of N/1000 sq ft if the annual release is 25 percent of the total. Since the recommendation for the total annual rate is 3.0 lbs of N/1000 sq ft, it must be noted that, if applications are made at the maximum amount of nitrogen recommended per application, 0.5 lb N/1000 sq ft, subsequent applications may overload the soil with nitrogen. This is because, over time, the un-released portion of nitrogen from the previous applications may become available for release at the same time that the subsequent applications are made. It is recommended that the subsequent applications be less than 0.5 lb N/1000 sq ft.

Table 3
Total pounds of nitrogen (N) applied per 1000 ft^2 from composts with various percent N composition and at various application rates. See Table 2 for the percentage of N in various types of compost.

Depth per year	Application rate		Range of percent nitrogen of compost* and total lbs nitrogen/1000 square feet*					
inches	cubic yards/ acre	tons/ acre	0.1 %	0.5 %	1 %	1.5 %	2 %	2.5 %
1/8	16.9	6.8	0.3 lb	1.6	3.1	4.7	6.2	7.8
1/4	33.8	13.5	0.6	3.1	6.2	9.3	12.4	15.5
1/2	67.5	27	1.2	6.2	12.4	18.6	24.8	31.0
1	135	54	2.5	12.4	24.8	37.2	49.6	62.0
2	270	108	5.0	24.8	49.6	74.4	99.2	124.0

†Adapted from the Composting Council, University of Missouri Extension
*Based on an average compost weight of 800 lb/cubic yard (wet weight)
Updated 9/14/11

Phosphorus: Table 2 also has a column for phosphorus as phosphate, P_2O_5; it shows the potential amount of phosphorus that is contained in various forms of compost. Unlike nitrogen, the majority of phosphorus in compost in many cases is immediately available. In manure-based composts, up to 85 percent of the phosphorus can be in the inorganic form and thus readily available to plants. This means that over-application of manure-sourced composts can lead to immediate run-off of phosphorus into the waters of Nantucket. Studies show that phosphorus in manure-based composts can substitute for synthetic forms of phosphorus on nearly a 1:1 basis. With manure-based composts, there is little margin of error for application rates, especially in the case of phosphorus. Special attention to depth and rate is imperative.

Since plant-derived composts, especially leaf litter, are lower in phosphorus content, they are recommended for use on most Nantucket soils, which are close to being at optimum phosphorus levels. Table 4 presents the phosphorus amounts that can be had from application of various forms of compost and for various depths. The amounts are based on 100-percent availability. If availability is less than 100 percent, then the available amount will be that shown in the table multiplied by the decimal form of the percentage available. For example, if the 1.6 lb compost was applied at 1/8 inch and was only 40 percent available, then the actual application would be 1.6 lb times 0.4 equals 0.64 lbs.

Table 4
Total pounds of phosphate (P_2O_5) applied per 1000 ft^2 in composts with various percent P composition and at various application rates. See Table 2 for the percentage of P in various types of compost.

Depth per year	Application rate		Range of percent P_2O_5 of compost* and total lbs of P_2O_5/1000 square feet*					
inches	**Cubic yards/ acre**	**tons/ acre**	**0.05 percent**	**0.5 percent**	**1 percent**	**1.5 percent**	**2 percent**	**2.5 percent**
1/8	16.9	6.8	0.2	1.6	3.1	4.7	6.2	7.8
1/4	33.8	13.5	0.3	3.1	6.2	9.3)	12.4	15.5
1/2	67.5	27	0.6	6.2	12.4	18.6	24.8	31.0
1	135	54	1.2	12.4	24.8	37.2	49.6	62.0
2	270	108	2.5	24.8	49.6	74.4	99.2	124.0

*Based on an average compost weight of 800 lb/cubic yard (wet weight)

Calculations

A fair question is "how does one get from one column in the tables to the other?" An example calculation may help. The numbers in bold are those that can be found in either table.

For compost that contains 0.5 percent of either N or P that is applied at ½ inch of depth:

67.5 cubic yards/acre * 800 lbs/cubic yard (wet weight) = 54,000 lbs/acre (**27** tons/acre);
54,000 lbs of compost/acre at **0.5%** = 54,000 lbs compost/acre * 0.005 = 270 lbs/acre;
To convert from lbs/acre to lbs/1000 square feet: 270 lbs/acre/43.56 = **6.2** lbs N/1000 square feet. The factor 43.56 is the number of 1000 sq ft in an acre, i.e. an acre is 43,560 sq ft.

Foliar Fertilizer

Foliar fertilizers are amenable to low application rates, including spoon feeding. For this Nantucket BMP, a foliar fertilizer is defined as any fertilizer product designed for uptake into a plant through its leaves; it is typically sprayed directly on top of the plant. This practice is popular with golf course managers and some gardeners on Nantucket. These products are not intended to reach the soil, but are to be taken up by the plant directly through foliage although some nitrogen is ultimately lost to volatilization. It is noted that some of this fertilizer may reach the soil for root uptake. For the plant to take up the nitrogen quickly, the form of nitrogen must be fast release.

Foliar fertilization consists of fertilizing turfgrass, ornamentals, and other plants through the application of a fine mist containing diluted and low concentrations of soluble quick-release fertilizer. This is one method of fertilizing with many applications of very small amounts of fertilizer and is sometimes referred to as "spoon feeding" and can be done as often as weekly or bi-weekly during the growing season. It is noted that this application rate is an acceptable exception to the guidance for those following the balance of the guidance on foliar fertilization. When the goal is root uptake of fertilizer, spoon feeding of granular fertilizers may be done independently of foliar fertilization.

When using foliar fertilizer, it is imperative that amounts of nitrogen be based on only what the plant can take up and utilize at each feeding. Rates of foliar fertilizer must not exceed 0.25 lbs. of nitrogen per 1,000 sq ft for any one application. Applications should be made a minimum of two weeks apart at any higher rates. Weekly applications can be made at lower rates between 0.10 and 0.125 lbs. of nitrogen per 1,000 sq ft. These rates may be impossible to achieve with granular fertilizers and should be applied only with liquid products in aqueous mists.

Typically, foliar fertilizer is taken up by the plant tissue in a matter of hours and is not intended to provide a longer release of nitrogen or other nutrients. Because of the low rates applied, the majority of foliar fertilizer does not reach the soil. This greatly lowers the likelihood of nitrogen or phosphorus reaching soils and leaching or running off the surface.

Rates of phosphorus should not exceed 0.25 lb of actual phosphorus in any one foliar fertilizer application, and should only be used if a soil test shows a phosphorus deficiency or if seeding is taking place. See Section 10. 'Turfgrass Establishment and

Renovation Guidelines' for more information about phosphorus rates and applications for turf establishment.

Fertilizer Calculations and Spreader Calibration: A Step by Step Guide

It is very important that fertilizer spreaders are correctly and regularly calibrated to ensure correct application rates for turf fertilizers. Spreader manufacture is not a precise process and, moreover, corrosion or caking can alter substantially the settings on a spreader. Hence there is a need for periodic re-calibration. Once fertilization requirements and rates for each application, are determined, calculations need to be made based on proper spreader calibration to ensure correct application rate of the fertilizer. Spreaders should be calibrated, at a minimum, once annually for each different product being applied. During periods of high use, a fertilizer spreader should be calibrated more often Detailed step by step instructions for spreader calibration are included in an Appendix (Appendix 6). It is noted again that fertilizers with high-percentages of nitrogen may not spread uniformly in most spreaders. This is because only a limited number of granules may be released in any one pass of the spreader.

The Weather Factor: The Importance of Avoiding Heavy Rainfall

Weather conditions and fertilizer are intricately and forever linked. Earlier in the BMP, application timing of fertilizer was discussed in regard to season and soil temperatures. Rainfall is as important to the breakdown of some fertilizers as is soil temperature. Large rainfall events or excessive irrigation coupled with improper fertilizer applications are one of the main causes for surface runoff and/or leaching of fertilizers. Inexpensive soil-moisture probes can be used to judge the existing amounts of soil water and to determine additional amounts needed to ensure moist conditions at root depth.

Prior to any application of fertilizer, a weather forecast (The National Weather Service is available at www.weather.gov; www.ackweather.com and several other commercial services are readily available) needs to be consulted. This consultation is not just for the day of application, but also for seven days following application. A long-range forecast can alert the applicator to upcoming storms and nor'easters, temperatures, and other factors that relate to fertilizer performance. Fertilizer applications that contain nitrogen or phosphorus should not be made prior to any forecast that calls for more than ½" of rainfall. Additionally, if the rain is forecasted to be ½" or less, but subject to be in intense form – such as a downpour during a thunderstorm – then fertilization should be postponed.

'Watering-in' is a technique used to begin the breakdown of water-soluble nitrogen or for any slow-release nitrogen (SRN) that depends on hydrolysis for release. 'Watering-in' can also reduce nitrogen loss from volatilization and can decrease the risk of runoff. Between 1/10" and ¼" of rain or irrigation is sufficient for the watering-in of fertilizer. Not all rain events can be accurately forecast, especially on Nantucket where many times rain forms in the ocean and radar doesn't pick up the bands. However, it is the responsibility of the applicator or homeowner to do their due diligence with regard to studying the weather report prior to fertilization. A rain gauge that measures the physical amount of rain that fell during a storm helps to distinguish rainfall from heavy fog or other high-humidity events.

Special Care and Clean-Up

Special care and cleanup must be taken when applying fertilizer. If any fertilizer spills or is spread on a sidewalk, driveway, etc., it must be swept and removed immediately. The excess removed should be added back to the bag or the spreader and used in remaining areas to fertilize. Prior to fertilizing a lawn or other turfgrass area, any exposed drains used for storm water, etc. should be covered with a small tarp or plywood to prevent fertilizer from falling into the drains. Again, any fertilizer remaining on the plywood or tarp should be added back to the bag or used in other areas to be fertilized.

Record Keeping

Keeping proper records of fertilization applications is necessary to track the amount of nitrogen, phosphorus, and other nutrients applied to any area. Record keeping also allows the applicator to compare actual results and performance at the end of the season versus what was planned for in the spring. Changes can, and should, be made for the following season to make better use of any products applied. Records should be kept for a minimum of seven years. When documenting applications, the following information should be recorded:

- Date,
- Names of applicators,
- Product used – trade name and analysis,
- Rate – product per 1,000 sq ft and nitrogen, phosphorus, etc. per 1,000 sq ft etc.,
- Keep a copy of the label to give information on the following:
    - Nitrogen sources, types, and percentages,
    - Phosphorus sources, types, and percentages,
    - Other nutrient types and percentages,
- Area(s) treated,
- Size of area(s),
- Weather conditions including temperature, rainfall, wind speed,
- Spreader or sprayer setting,
- Amount of product used,
- Any additional comments regarding application.

A sample sheet for record keeping is included in Appendix 6.

Examples of Three Turf Fertilizer Management Programs

In the appendix (Appendix 7), there are presented three different fertilizer programs that were designed for a homeowner-maintained lawn that is under-performing. The hypothetical soil-analysis test for this plot had a pH of 5.3, which is below the optimum range; it was very high for phosphorous; very low for potassium; and low for magnesium. Organic matter was 3.4 percent, which may be as good as we can get for Nantucket.

These fertilizer management programs are presented for turf on a typical Nantucket soil:

- an organic fertilizer-based program;
- a synthetic fertilizer-based program; and
- a hybrid program based on a combination of organic and synthetic fertilizers.

Each program provides recommendations for type of fertilizer, application rates, and timing of applications and related cultural practices.

Source Material

This section was written by Nantucket landscapers led by Mark Lucas. It was reviewed carefully by the external reviewers listed in the Acknowledgements section.

Section 9

Turf Establishment and Renovation Guidelines

- **Detailed steps for establishing a lawn from seed or sod, and for renovating a damaged or underperforming lawn, are explained.**
- **The importance of the soil test as the basis for determining nutrient and other soil deficiencies, and correcting them, during establishment or renovation is emphasized.**
- **Special care when including phosphorus application for germination and establishment is emphasized.**
- **Using certified seed and pre-germination of seed are recommended.**
- **Careful monitoring of soil moisture and appropriate watering practices during seed germination and establishment are stressed.**
- **Recommendations for follow up fertilization and mowing timing and height are provided.**

While many of the principles for establishing and renovating lawns are the same as for maintaining them, special care needs to be taken to avoid the run off or leaching of fertilizers, especially when applying seed to bare soil, while roots are becoming established. The following guidelines, when followed, should ensure that the fertilizer application necessary for establishment and renovation of turf, will be taken up by the turf for which it is intended, and not run off or leach.

Late summer or early fall is the ideal time of the year to establish or renovate a lawn on Nantucket. During these times, soil temperatures are still warm, there is plenty of sun, and there tends to be more moisture available for maximum seed germination. The ideal starting time of late summer allows time for plants to establish roots through the fall and become mature enough to survive the winter. Establishing a lawn in the spring or summer almost always requires more water, fertilizer, and possibly herbicides to control competition from weeds that are more prevalent in the spring and summer than in the fall. If late summer or early fall is not a feasible time for establishing a new lawn, consideration should be made for establishing the lawn with sod instead of seed.

Establishing a Lawn from Seed: A Step-by-Step Guide

1. Obtain a soil test – A comprehensive test is recommended to obtain as much information as possible. At a minimum, the following items should be analyzed: phosphorus, potassium, pH, estimated nitrogen release (ENR) for the potential availability of nitrogen, and organic-matter percentage. Having a baseline test will help determine the amount of soil modification necessary. Refer to Section 4. "Soil Nutrient Analysis: The Importance of the Soil Test" for more information on obtaining and applying the soil-test analysis.

2. Rough grade the site – Grade to remove stumps, large rocks, and debris. Fill in any low areas and grade away high areas. Areas should be contoured to achieve a desired surface drainage pattern. Always grade away from structures.

3. Modify the soil – Amend the soil based on the soil-test analysis providing a 6" -8" depth of amended topsoil for a healthy turf root zone. Soils, if necessary, should

4. Adjust pH – Adjust pH if necessary. A pH between 6.0 and 7.0 is preferred for most turfgrasses. Dolomitic or high-calcium lime may be necessary to correct calcium and magnesium deficiencies, or to raise soil pH. Use a calcitic (non-Mg) limestone if magnesium is not needed. Incorporate lime into the root zone, which is generally the top 4-6 inches.

5. Fine grade the site – This is an important step since it will create the final surface for seeding. If an irrigation system is installed, final grading should follow its installation. If any further incorporation of compost and/or fertilizer is needed, such as in step 6, final grading should occur after incorporation.

6. Apply a starter fertilizer and/or compost for seed germination – If a soil test reveals a deficiency, a starter fertilizer or compost can be applied after germination. If compost is incorporated into the soil prior to seeding, and depending on the phosphorus content of the compost, a starter fertilizer will likely not be necessary. For successful seedling germination, and subsequent seedling root growth, phosphorus is a necessary nutrient. If available phosphate in the soil is found to be low, phosphorus may be applied after germination according to soil test recommendations. Though phosphorus in the soil is not very mobile, surface runoff of phosphorus is a concern, especially near freshwater wetlands. If a nitrogen source is used, it should conform to the guidelines stated in section 8. It is preferable to fertilize with a nitrogen source after germination when the plant will require nitrogen for growth, as it does not need or take up nitrogen until after germination.

7. Seed – Certified seed is strongly recommended to guarantee cultivar authenticity. See Section 7. "Turfgrass Blends and Selection" for further information regarding different seed species, mixes and blends. Proper seeding rate is also very important. Applying seed quantity above or below the recommended rate can create problems while establishing a lawn. If the soil is dry, it should be lightly irrigated before applying seed. Spread seed and lightly rake for ideal seed-to-soil contact. Maximizing seed-to-soil contact for good germination is critical. Rolling is another option after raking to help insure that the seed, and any fertilizer, are more likely to stay in place following irrigation and/or rainfall. If hydro-seeding, be sure to specify seed mix, rate, and fertilizer content, if any, of the hydro-seed solution.

8. Protect the seed – It is very important that seed not dry out between application and germination. One good way to protect the seed is to apply it as hydroseed,

9. Irrigate – Hand water or irrigate frequently (2-3 times a day depending on weather conditions) to a shallow depth, to ensure that the seed remains moist at all times. Seed that consistently dries out after it has been moistened is less likely to germinate. It is important to keep the soil moist, but not saturated, until seedlings are about an inch high. As seedlings grow, reduce the frequency of watering, but increase the duration of each watering to promote recharging the root zone, which encourages root development. At this time it is also important to allow the surface to dry between irrigation events.

10. Mow – A lawn should be mown for the first time when the grass is a third higher than the desired mowing height. For example, if the desired height is 2 inches, mow for the first time when it reaches between 2.5 and 3 inches.

11. Fertilize – After the first or second mowing, a follow-up fertilizer application is recommended with a 25 to 50-percent WSN form of nitrogen. The recommended application rate is 0.5 lb N per 1000 sq ft. There is no reason to apply phosphorus at this time unless a soil test indicates a deficiency. During the year of establishment, no more than 3.0 lbs N/ 1000 sq ft should be applied.

Establishing a Lawn with Sod: Step by Step

In some instances, selecting sod over seed to establish a lawn may be appropriate. For example, if a lawn needs to be established in late fall, using sod is a better alternative to establishing from seed. The following lists a series of steps to take when establishing a lawn from sod.

(Repeat steps 1 – 5 from above)

6. Install the sod – Quality sod should be chosen, and because it is transported from off-island sources, special care and attention needs to be paid to keep it from being damaged before it is laid. Prevent drying out or over-heating prior to installation. Sod should be laid as soon as possible from the day that it was cut. Soil attached to

sod should be as close as possible in texture and other physical properties as the soil of the prepared sod bed. Sod can often be grown in soils high in clay, and the clay 'layer' is cut with the turf. This clay layer may impede air and water movement and also reduce the uptake of nutrients. Ask the supplier to supply as little clay as possible. The sod bed should be irrigated to a depth of 3-4 inches prior to laying the sod to promote rapid establishment. Be sure to stagger seams and to pull sod pieces close together to reduce the possibility of gaps developing between pieces. These can be sites for weeds to develop later.

7. Roll and hand water – The sod should be lightly rolled to smooth out any inconsistencies caused by foot traffic prior to watering. The sod should be hand-watered immediately after rolling.

8. Irrigate – Sod, once installed, should be irrigated regularly to keep the soil moist and promote root establishment. Frequency and amount of irrigation should be closely monitored to keep the sod from drying out and the root-zone moist. As with establishing seed, more frequent lighter watering is required at first, to keep the sod moist, with less frequent but deeper watering to replenish the root zone, as the sod sends down roots as it becomes established. Weather, especially wind and precipitation, must, as always, be carefully monitored and factored into adjusting irrigation.

9. Should gaps develop in the seams, top dress those areas with a mix of compost and grass seed that is compatible with the newly installed sod.

10. Fertilize – Approximately 3-4 weeks after installation, when the sod has begun to root, apply an application of a fertilizer in accordance with the guidelines in section 8; phosphorus should be included only if a soil test indicates a deficiency.

Renovating an Existing Lawn: Step by Step

Renovation allows for improvements to be made to an existing lawn without the need to re-establish the entire lawn or to start "from scratch." Renovation is typically chosen to correct problems with existing lawns. Underlying problems that are causing a lawn to under-perform need to be identified before starting the project and then corrected during the renovation process. The following lists a series of steps for renovating an existing lawn.

1. Diagnose and correct – Determine the underlying problems requiring the renovation and correct them. Underlying problems may include poor soil, poor drainage, soil layering, weed content above acceptable levels, or improper grasses for Nantucket.

2. Obtain a soil test –Obtain a soil test 3 to 4 weeks ahead of work, if possible, to allow time for any adjustments to soil pH. Any deficiencies in the existing soil should be corrected during the renovation process. Refer to Section 4. "Soil

3. Prepare for amendments and seed. If thatch levels are high, aggressive aeration or de-thatching may be necessary to prepare a good seed bed. The lawn should be mown very low, to one inch or lower to allow for the new seed to compete for sunlight and water within the existing stand of grass.

4. Add soil amendments. Top dress and incorporate compost into the soil if the soil test indicates low organic matter (OM). See Section 5. "Building the Soil" for compost rates. Core aeration must be done prior to top dressing with compost to allow it to penetrate below the existing layer of grass. A phosphorus-based fertilizer can be applied if levels are deficient, and nitrogen (N), should be applied in accordance with the guidelines in section 8.

5. Seed – Spread seed, lightly rake, and roll the area if possible for good soil-to-seed contact. The seed should have adequate protection from the existing turf, even if that turf has died. Seed can be pre-germinated for quicker establishment. To pre-germinate seed, place it in a cloth bag, and soak in a barrel of water for at least 12 hours, depending on grass species selection. Aerate by lifting the bag out of the water and placing it back several times every few hours. Spread seed out to dry just sufficiently enough to go through the spreader before application with a spreader.

6. Irrigate – Irrigate in the same manner as for new seedlings to ensure that the seed remains moist at all times while germinating. Overall irrigation needs will be reduced if the seed has been pre-germinated.

7. Mow – The lawn should be mown for the first time when the new grass is a third to one-half higher than the desired mowing height.

8. Fertilize – Approximately 1-3 weeks after germination, the lawn can be fertilized in accordance with the guidelines in section 8. This application rate should be no more than 0.5 lb N per 1000 sq ft. Phosphorus should not be applied at this time unless a soil test indicates a deficiency. During the year of establishment, no more than 3 lbs N per 1000 sq ft should be applied.

Section 9. Bibliography

- Best Management Practices for Lawn and Landscape Turf. University of Massachusetts, Extension,
- 2010-2011 Professional Guide For IPM In Turf For Massachusetts, 104 pp. (UMass BMP)
- Sachs, Paul D., 1996, Handbook of Successful Ecological Lawn Care. The Edaphic Press, Newbury, Vermont.

Section 10

Turf Care Cultural Practices

- **Cultural practices for turf maintenance include mowing, aeration, de-thatching, top-dressing, and spiking/slicing.**
- **Mowing height and frequency should follow the one-third rule. Sharp mower blades help maintain healthy, attractive turf.**
- **Leaving clippings in place is recommended. Returning clippings can add up to 33 percent of nitrogen (N) needs per season, allowing N fertilizer application to be reduced accordingly.**
- **Core aeration removes plugs of soil, alleviating compaction, removing thatch, and enhancing the movement of air and water to plant roots.**
- **Top-dressing is the spreading of compost or other material over established turf: one benefit of which can be to increase organic matter content. Core aerate prior to top-dressing.**
- **Mechanical de-thatching reduces excess matting below the plant crown, enhancing water and air penetration into the turf.**
- **Spiking/Slicing is the mechanical cutting of small vertical slices into the soil, enhancing water and air penetration into the turf.**

Mowing, core aerating, dethatching, and top-dressing, are all examples of cultural practices. The following practices help maintain healthy turf, and some directly reduce rates of fertilizer applications.

Mowing

Mowing is obviously the most basic cultural practice used to manage turf and plays a large role in its health. Improper mowing, however, can cause tremendous stress and damage to turf. The following mowing practices directly influence the vigor and health of turf, and in some cases, reduce rates of annual fertilizer amounts.

Mowing height. Mowing height is of primary importance to the health of turf. Some Nantucket lawns are mown at lower than optimum height for aesthetic reasons. Unfortunately, mowing at a lower height can damage turf, particularly for certain grass species, by limiting root growth and production, carbohydrate uptake, and stress tolerance. Mowing higher, particularly during times of extreme heat or drought, is especially important to turf vigor. For example, if mowing is done at a height of 2 inches instead of 3 inches in July, water-use efficiency may decrease, fungal pressures may increase, fertilizer requirements may increase, and tolerance to heat and drought may be reduced. Fertility requirements increase with certain species when they are mown too short, due to most of the nutrients being utilized for shoot development instead of other parts of the plant, such as roots. Simply raising the height to 3 inches may decrease, or eliminate these stresses.

Sharp blades/Clean cuts. Proper blade, reel, or bed-knife sharpening is also important for healthy turf. The importance of sharp mowing blades cannot be over emphasized. The tearing or ripping of grass blades, instead of leaving clean, sharp cuts, creates unintended wound surfaces where pathogens can more easily enter and spread disease. The jagged ends also increase water loss. These wounds also give a ‘brownish’ look to the lawn until the grass grows out past the point of the wound. Mower blades should be sharpened after every 8 hours of use for professional lawn mowing, if possible.

Mowing frequency. Removal of more than one third of top growth at any given time can directly slow or stop root growth. Because the degree of root growth is crucial to the success of a healthy turf, whenever possible mowing frequency should be based on how fast or slow the grass is growing, adhering to the 'one-third rule'. To give an example of how to follow the one-third rule, if a three-inch minimum height is desired, then the lawn should be mowed when the grass is 4 inches tall. This is a maximum and mowing may occur at any time provided that three inches remains after mowing.

Recycling clippings

Recycling clippings over the course of the growing season can add up to 33 percent (1.0 lb N per 1000 sq ft) of the annual nitrogen, N, requirement. Mulching mowers, designed to chop mown grass into fine pieces, not only recycle N but also increase mowing efficiency as bags don't need to be emptied or clippings hauled away. Because lawn clippings from either a mulching mower, or a reel mower, are composed of easily degradable compounds, they break down rapidly and do not contribute to thatch buildup.

Core Aeration

Core aerating the soil is one of the most beneficial cultural practices for compacted lawn or turf surfaces, especially on heavy-use lawns, playing fields, and irrigated lawns. It not only alleviates surface compaction but also increases microbial activity and allows oxygen to enter while carbon dioxide and other harmful gases exit. Aeration also helps reduce excess thatch. Thatch is necessary at small levels to cushion the crown of the plant and provide some water and nutrient-holding capacity. However, excess thatch levels lead to increased water requirements, decreased fertilizer efficiency, decreased root vigor, increased insect pressure, and more disease susceptibility. High-use lawns or playing fields are recommended to be aerated a minimum of once a season. Aeration is preferred in the fall when lower temperatures will aid in recovery.

De-thatching/Verticutting

De-thatching, also known as verticutting, is a practice that uses vertical blades to slice through the turf canopy and, depending on the depth setting, into the thatch. It also helps clean the surface, and mat area (zone between crown and thatch) of any accumulated debris. This practice can contribute to reduced water use, increase the efficiency of fertilizer uptake, and decrease the incidences and severity of turf diseases.

Top-dressing

Top-dressing is the application of a layer of material, such as sand or compost, across the turf surface or into the root zone after core aeration. The sand or compost is then brushed into the turf canopy and eventually finds its way into the thatch layer. Top-dressing can help dilute thatch, provide protection for the crown of the plant, and smooth out low areas. Top-dressing can increase nitrogen utilization and water infiltration while decreasing water use. Top-dressing with compost also adds beneficial microbes and bacteria to increase microbial activity while building the soil. Compost usually contains nitrogen and phosphorus, so it is important to know the amount of each before making applications. Compost is typically low in nitrogen, but, depending on the source, can be higher in phosphorus. Top-dressing immediately after core aeration can be very beneficial, and there is less chance that compost will form 'bands' of phosphorus or nitrogen compared to repeated surface applications.

Spiking/Slicing

Spiking or slicing is the cutting of spikes or slices, 1-3 inches deep into the subsurface. While these practices do not relieve compaction or control thatch, they do allow oxygen to enter the root zone, improve water infiltration, and provide a good environment for over-seeding and repairs.

Section 10. Bibliography

- Best Management Practices for Lawn and Landscape Turf. University of Massachusetts, Extension,.
- 2010-2011 Professional Guide For IPM In Turf For Massachusetts, 104 pp. (UMass BMP).
- Sachs, Paul D., 1996, Handbook of Successful Ecological Lawn Care. The Edaphic Press, Newbury, Vermont.

Section 11

Fertility Guidelines for Perennial Gardens, Ornamental Trees and Shrubs

- **Fertility guidelines for herbaceous perennial gardens and ornamental trees and shrubs are recommended and are based on the principles of building healthy soil.**
- **The importance of soil tests as the basis for adjusting soil with fertilizer or amendments and for maintaining proper soil pH is stressed.**
- **Compost addition is recommended for increasing soil organic matter and nutrient content, increasing soil microbial activity, and increasing soil nutrient and moisture retention capacity.**
- **The importance of phosphorus for flowering plants, its presence and availability in Nantucket soils, and its harmful impact on fresh water resources is emphasized.**
- **The ingredients of compost are highly variable with respect to their content of nutrients: nitrogen, phosphorus, and potassium. Knowledge of nutrient content is derived from labels of commercially available composts and from knowledge of the compost source for home-produced composts. If in doubt about nutrient content, the compost should be tested before it is applied to a Nantucket soil.**

Perennial Gardens and Mixed Borders

Herbaceous perennial gardens, or mixed borders, are popular components of many residential Nantucket landscapes. A mixed border may consist of ornamental shrubs, grasses, and perennial flowering plants. The growth and vitality of these types of plantings depends on some of the same principles that apply to turf, with a notable exception. Most perennials, shrubs, and other ornamental plants do not require significant amounts of supplemental fertilizer, if the soil is well amended with nutrient-providing organic matter, and a proper pH is maintained. Annual or seasonal fertilizing may not be necessary in a perennial or mixed garden with well-amended soil. Fertilizer should only be applied if a lack of plant health or vitality has been observed and after a soil test has identified a specific deficiency and recommended how to correct it.

Building the soil by preparing a proper depth of well-amended and well-drained topsoil with the correct pH, ideal percentage of organic-matter content, and essential nutrients is the key to successful ornamental gardens. The recommended depth of amended topsoil for a perennial garden or mixed border is 8- 12 inches. The proper amount of organic matter and other soil amendments needed is determined by the soil-test analysis. A soil test is the only way to know exactly what a garden soil may need, and must be consulted before applying any nutrients, especially the three macronutrients: nitrogen, phosphorus, and potassium. A follow-up soil test is recommended approximately eight weeks after the addition of compost and any other nutrients to allow any amendments to stabilize and provide the most accurate assessment of nutrient levels in the soil. Gardeners should be aware that many forms of compost contain excessive levels of phosphorus and should only be applied with knowledge of specific content and source. The reader should refer to Section 4. ‘Soil Nutrient Analysis’ for details on obtaining, and interpreting, a soil test. After a new garden is established, it is recommended to test the soil every year to determine any deficiencies and prescribe any fertilizers necessary to maintain plant health and vitality.

Special care needs to be taken if applying granular fertilizers to gardens, mixed borders, or landscape plantings, because fertilizer applied on bare soil between plants, makes it more likely to run off before being absorbed by the plants it is intended for. When applying fertilizer to garden beds it is recommended to mix the fertilizer into the top two inches of the garden soil to discourage surface runoff.

The recommended pH for most garden soils is 5.5-6.5. The optimum recommended organic matter (OM) content is 3 percent for Nantucket. As noted before, this is somewhat below that of soils with more clay and silt content than exists on Nantucket. Where topsoil has been imported, the optimum OM level may be somewhat higher. Compost is the recommended amendment for increasing OM and although the amount added should depend on the soil-test analysis and the depth of soil desired, recommended practice for most sandy Nantucket topsoil is to incorporate an inch or two of compost when preparing an 8- 12-inch depth of garden soil. As suggested previously, vegetation-based (leaf litter) compost is preferred on Nantucket.

Of the three macro-nutrients included in most fertilizer blends, phosphorus (P) is one of the most important for success with flowering plants. Phosphorus is a limiting environmental nutrient for fresh water wetlands, so extra care needs to be taken before applying this nutrient in Nantucket gardens, especially near any of our many freshwater ponds. Many of Nantucket's soils test naturally high for P, and therefore, phosphorus should not be added to the soil unless a soil test shows a deficiency. If a soil test shows a P deficiency, follow the recommended rate and the product suggested to correct it.

Refer to section 2. "Nitrogen and Phosphorus and Plant Growth" for more information on the variables of phosphorus availability in Nantucket soils. One important note is that pH levels influence phosphorous availability. "Fertilizer Types and Sources" in the appendix gives details on sources and types of phosphorus fertilizers. A quick-release source of phosphorus such as "triple super phosphate," popular in garden uses, is not recommended for Nantucket gardens unless a soil test specifically recommends it.

As with turf, climate plays an important role in the timing of fertilizer applications for ornamentals. Supplemental fertilizers, if necessary, are best applied in the spring after active growth of plants is observed. The time of active spring growth on Nantucket ranges between mid April to mid May, or later, depending on the exact location and microclimate of the garden.

A top dressing of compost, applied and mixed into the soil in spring or fall, may be enough to replenish soil nutrient levels when or if they go down over time. Again, a soil test analysis should be the basis for deciding how much compost to add.

Ornamental Trees and Shrubs

As with other landscape plantings, proper soil analysis and preparation is the key to the success of ornamental trees and shrubs on Nantucket. With a well-amended, nutrient-balanced soil, supplemental fertilizers for most trees and shrubs may not be necessary and if applied unnecessarily or inappropriately may leach or run off to harm Nantucket's water resources.

The bibliography lists sources for further information on the wide range of ornamental plants used on Nantucket.

Section 11. Bibliography

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- Horticulture Gardener's Desk Reference. 1996, Macmillan.
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Section 12

The Role of Irrigation

- **Placement of the irrigation system should be included in the initial site planning process and included in the final as-built plan.**
- **Irrigation zones should be tailored to the requirements of specific plantings including turf, gardens, or mixed borders.**
- **Irrigation water should not penetrate below the root zone. A simple soil probe or spade can be used to determine depth of moisture from irrigation.**
- **Regular monitoring and adjustment of irrigation control clocks over the course of the growing season is important to provide adequate moisture for plants without overwatering. Excess irrigation contributes to run off or leaching of fertilizer and wastes water.**
- **Special monitoring of irrigation at times of planting, fertilization, and renovation is essential for promoting healthy plant growth and avoiding run off or leaching.**
- **Turn irrigation systems off during periods of adequate rainfall. Avoid watering impervious surfaces such as sidewalks, driveways and roads.**
- **Seasonal record keeping of natural precipitation and clock adjustments is recommended.**

Properly designed, monitored, and maintained irrigation systems play an important role in managed landscapes and gardens on Nantucket. Proper water management promotes healthy landscapes, while reducing the leaching of fertilizers into our groundwater, ponds, and harbors.

System Design

The design of an irrigation system for a new landscape should be based on careful site planning as outlined in Section 3. The location and separation of the system into different zones should be tailored to specific site conditions as well as the water needs of the different aspects of a proposed landscape. For example, a lawn, or the part of it on a windy exposed site will require more water than a lawn in an area more protected from the wind. Turf has different water requirements than a shrub border, or a perennial garden. Some shrubs popularly used in Nantucket gardens, hydrangeas for example, need more water than others that are more adapted to Nantucket's conditions. A border of native plants may not need much water at all after becoming established.

An as-built map or diagram showing the numbered irrigation zones of the particular landscape and garden is a useful tool for both the professional landscaper and the homeowner for effectively understanding and monitoring their system. Keeping irrigation clock labels properly updated over time and when changes are made to systems is important.

System Monitoring

An important irrigation factor to consider is that new landscapes initially require more water as turf and plants are becoming established. Close observation of watering needs over time will usually lead to less water being used as plants and turf mature, except, of course, during times of extreme heat and drought.

Regular monitoring of the irrigation system over the duration of the growing season is fundamental to using water efficiently and avoiding over watering, which may increase the possibility of fertilizer leaching or surface run off. Coordination of watering with fertilizer applications is especially important during the growing season. For example, when a turf fertilizer has just been applied, providing the correct amount of water to replenish just the root zone is crucial in avoiding leaching of the fertilizer to groundwater. The depth of the root zone and penetration of water from irrigation or rainfall can be easily determined with a simple soil probe or shovel. In an inconspicuous spot or at the exposed edge of a bed, one exposes a small vertical face of soil and measures the depth to dry soil.

A recommended component of monitoring irrigation is to keep a written journal of clock adjustments and weather conditions over the growing season. Adjusting the landscape-irrigation system during the growing season so that irrigation supplements natural rainfall patterns is a recommended practice. It is important to avoid over watering, which may harm the health of turf and gardens, as well as Nantucket's water resources, especially just after fertilizers are applied. The simplest way to avoid excess watering is to remember to turn your irrigation clock to "water off" when it is raining. Wait to turn it back on until conditions warrant.

In summary, irrigation systems are very useful components of successfully managed landscapes and gardens. The importance of seasonal and long-term monitoring and clock adjustment in conjunction with plant-growth needs, and weather conditions are both important aspects of a successful irrigation system. One should only use watering recommendations that are based on weather information (http://www.nrcc.cornell.edu/grass/). Even better is to have your own rain gauge to adjust watering recommendations to the specific amounts of rainfall at your site.

Irrigation-system design based on specific site conditions, regular maintenance and adjustment over time, and especially close monitoring and record keeping during the growing season will all help direct fertilizers to the plants they are intended for while promoting healthy landscapes with minimal risk to nutrient run off or leaching to our ponds, harbors and ground water.

Source Material for Section 12

This section was written by Seth Rutherford of Waterworks of Nantucket.

Section 13

Alternative Naturalistic Style Practices

- **Native plants are plants that occur naturally in an area and were not introduced by people. Naturalized plants were introduced by people and have adapted to natural conditions.**
- **Preserving existing areas of desirable native plants is encouraged in the site planning process.**
- **Native or naturalized plants are recommended in managed landscapes as ornamental plants, borders, or buffers.**
- **Native and naturalized plants are well adapted to local conditions, and are generally easy to maintain. They do not require fertilizer or irrigation beyond establishment, are often resistant to diseases and pests, and support native biodiversity.**
- **Invasive exotic plants are introduced species that aggressively displace native species. Removal of invasive exotic species is recommended where possible.**

The naturalistic style of landscape design and management takes its cues from existing plant communities and conditions and an understanding of how they develop and change over time. It is an approach that is based on knowledge of and adaptation to self-sustaining landscapes that exist all around us on Nantucket. It helps to maintain the "Nantucket Look."

Naturalistic-style landscapes require little to no alteration of existing conditions, no irrigation, and no fertilizer inputs. Entire individual properties can be designed and managed in a naturalistic style, or, more realistically, some naturalistic style practices can be incorporated as components of higher-maintenance landscapes. Thorough site assessment and planning determines how much of a particular property is desired or needed for fertilizer-dependent turf or plantings, and how much can be managed naturalistically, whether restored or left undisturbed.

The principles and practices of naturalistic landscaping are closely related to the science of ecological restoration but on a smaller scale. For further information on ecological restoration and alternatives to lawns, refer to the bibliography for a list of recommended reading.

Native Plants

There are many benefits to using native plants in manmade landscapes. Native plants are those that have evolved naturally in an area, in our case Nantucket, with its own unique setting, history, and conditions. Specifically, native plants refer to plants that were growing here before humans introduced plants from distant places. Native plants consist of plant species and communities adapted to similar soil, moisture, and climate conditions. The native plants we have on Nantucket today are also influenced by the impact of historical land uses including grazing and farming practices, as well as the relatively recent introduction and spread of invasive plant species.

One of the primary benefits of using native plants is that once established, they require no fertilization or irrigation. Other benefits are winter hardiness, drought tolerance, and for most species, increased pest and disease resistance.

Naturalized Plant Communities

Over time, plants introduced from around the world have adapted to Nantucket's conditions, and become naturalized. Some of these are common in natural areas and many would mistake them as natives. Examples of naturalized plants are Rosa rugosa, found in stands on sand dunes, most all of the pines growing on the island, and common roadside weeds or wildflowers, such as Queen Anne's lace and common daisies. Some introduced plants have great competitive advantage over native plants and are considered exotic invasives. A few examples of exotic invasives on Nantucket are Japanese Knotweed, Polyganum cuspidatum, which has a bamboo-like appearance and spreads rapidly forming dense monocultures, Japanese Honeysuckle, Lonicera japonica, one of the first shrubs to leaf out in the spring and gaining a dominant foothold in more and more areas of the island, and oriental bitter sweet, Celastrus orientalis, a very aggressive vine with orange and yellow berries that is unfortunately used for decorating inadvertently promoting its spread. Exotic invasives tend to be found predominantly on disturbed lands and old dumping grounds. They are continuing to spread and altering native plant communities. When preserving naturalized plant communities as part of the landscape, one should remove exotic invasives, where possible, to encourage native plant communities.

As with all plant communities, naturally occurring vegetation continues to change over time. An understanding of what factors influence past, present and future changes is fundamental to implementing management decisions for natural areas if incorporated as part of the manmade landscape. Preserving an area of undisturbed plant communities or planting with native plant species are two very distinct naturalistic style practices.

When a nursery-grown native plant is planted in an amended garden soil, it will perform differently from the same native species existing in Nantucket's natural soil conditions. One of the keys to successful use of native plants is to replicate the natural conditions the native plant grows in. The second is to carefully monitor the transition from nursery-grown plant to established landscape plant. The seasonal timing of planting and the size of the plant are contributing factors to the successful use of native plants. The ease or difficulty of establishment varies species to species. The third factor in the successful use of native plants, once established or preserved, is to manage them appropriately, which means hardly at all. It should not need mentioning but one should source native plants from commercial nurseries, several Nantucket ones stock them, and not by "rustling" them from our conservation lands.

As mentioned in Section 3. 'Site Assessment and Planning,' it is common for building construction practice in rural parts of the island to disturb more area than will be necessary for a well-planned manmade landscape. Those extra areas, between the designed functional landscape, and undisturbed land beyond, are opportunities to incorporate alternative naturalistic landscape practices. The primary benefit, as it relates to the BMP, is the overall reduction of fertilizer use, by applying alternative plantings that require no fertilizers. A corollary benefit is the aesthetic softening of edges between the closer, 'tamed' landscape, and the surrounding 'wild' natural areas beyond.

Tall Grass Meadows

One recommended practice for restoring disturbed land is to plant areas with natural grass lands, which are primarily based on warm-season species of grass. Sand-plain grassland, one of Nantucket's special natural plant communities, is an excellent model for a grassland. Little bluestem, Schizachyrium scoparius, switchgrass, Panicum virgatum, and Pennsylvania sedge, Carex pennsylvanica, are three native-grass species that work well for meadow planting. It is important to use existing Nantucket soil, not to fertilize, and only to water during extreme drought periods when a grassland is being established. Amended soil, fertilizer, or added irrigation will encourage competitive weed growth and out-compete native grasses that are adapted to our soils and climate. In time, with selective hand removal of unwanted species that may come in, and once or twice a year mowing (at a recommended height of 3-4 inches), a grassland will mature and even incorporate other native species that grow from seed found in native soil and surrounding vegetation. The land above and around a newly installed or repaired septic system leach area is a recommended location for establishing a grassland.

Using Native Trees and Shrubs

Shrub buffers, whether of newly planted or of preserved existing vegetation, are another example of naturalistic style practice, that when used, reduce fertilizer inputs. If a preserved shrub thicket is included as an edge planting or integrated part of a manmade landscape, it requires no fertilizer or water. Unlike some hedge materials such as privet, the naturalistic planting may require little maintenance or pruning. The following are some recommended native shrubs and trees for buffer plantings, readily available in local nurseries. Cultivars and varieties of many native species have been selected or developed for landscape use.

Table 4.
Nantucket Native Shrubs and Trees

Shrubs:	Bayberry (Myrica pennsylvanica)
	Viburnum (Viburnum dentatum)
	Beach plum (Prunus maritime)
	Inkberry (Ilex glabra)
	Winterberry (Ilex verticillata)
	Sweet pepperbush (Clethra alnifolia)
	Highbush Blueberry (Vaccinium corymbosum)
Trees:	American Holly (Ilex opaca)
	Red maple (Acer rubrum)

Sassafras (Sassafras albidum)
Tupelo (Nyssa sylvatica)
American Beech (Fagus grandifolia)

Native plants and plant communities, when planted and established correctly, do not require fertilizers or irrigation, thus reducing potential nutrient leaching into our water.

Section 13. Bibliography

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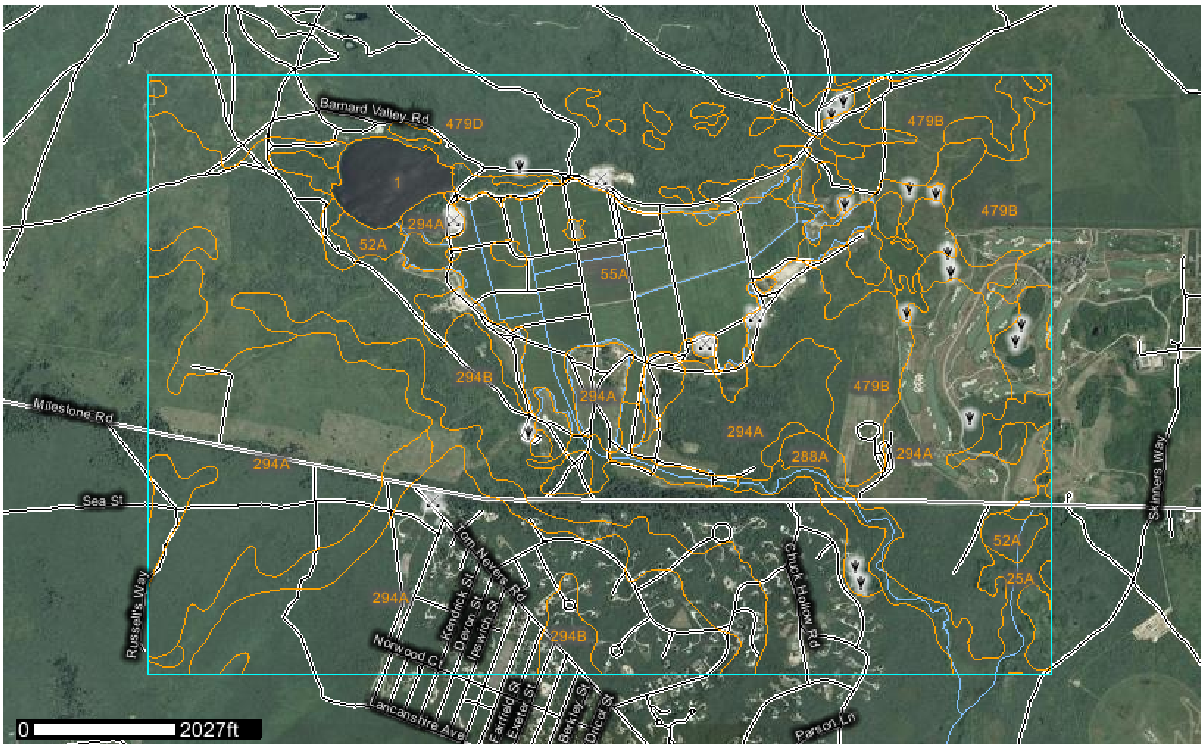
- Apfelbaum, Steven I. and Alan W. Haney. Restoring Ecological Health to Your Land.
- Tongway, David J., John A. Ludwig. 2011. Restoring Disturbed Landscapes: Putting Principles into Practice.

Appendices

Appendix 1. Soil Maps

The inclusion of the soil map is meant for Nantucket landscapers, amateur and professional, to see what information is available to them about soils. One should follow the web links, create an “Area of Interest” that includes your specific property and then open the pages of information available.



Nantucket County, Massachusetts (MA019)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	36.1	1.5%
25A	Berryland Variant loamy sand, 0 to 3 percent slopes	59.8	2.4%
52A	Medisaprists, 0 to 1 percent slopes	76.1	3.1%
55A	Medisaprists, sandy surface, 0 to 1 percent slopes	219.2	8.9%
261A	Tisbury very fine sandy loam, 0 to 3 percent slopes	0.4	0.0%
288A	Riverhead sandy loam, 0 to 3 percent slopes	9.5	0.4%

Nantucket County, Massachusetts (MA019)

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
293B	Riverhead-Nantucket complex, 3 to 8 percent slopes	20.8	0.8%
294A	Evesboro sand, 0 to 3 percent slopes	863.6	35.2%
294B	Evesboro sand, 3 to 8 percent slopes	507.1	20.7%
294C	Evesboro sand, 8 to 15 percent slopes	101.1	4.1%
295A	Klej and Pompton soils, 0 to 3 percent slopes	40.0	1.6%
479B	Plymouth-Evesboro complex, 3 to 8 percent slopes	215.3	8.8%
479C	Plymouth-Evesboro complex, 8 to 15 percent slopes	30.0	1.2%
479D	Plymouth-Evesboro complex, 15 to 25 percent slopes	265.3	10.8%
600	Pits	2.0	0.1%
652	Dumps	8.7	0.4%
Totals for Area of Interest	2,455.0	100.0%	

This map can be recreated at http://websoilsurvey.nrcs.usda.gov.

Appendix 2. Recommended Soil Testing Laboratories

- A & L Analytical Laboratories, Inc., 2790 Whitten Road, Memphis, TN 38133

Phone 800 -264-4522; 901-213-2400
Fax 901-213-2440
http://www.al-labs.com/

- UMass Soil Testing

Soil and Plant Tissue Testing Laboratory, West Experiment Station
682 North Pleasant St., University of Massachusetts
Amherst, MA 01003
http://www.umass.edu/soiltest

Appendix 3. Sources and Types of Fertilizer

3. A. 1. Sources and Types of Fast-Release Nitrogen Fertilizer

Urea. Urea is the most widely used of all fertilizers. It is fast release or quickly available, unless treated or chemically altered to make it slow release (SRN). It is the main constituent of synthetic SRN products. Microbial activity is initially required for breakdown of nitrogen, and thereafter water. Urea is susceptible to leaching if improperly used or used in excess of the rate guidelines in Section 8.

Ammonium sulfate. Ammonium sulfate is usually stated on a fertilizer label as percent ammoniac nitrogen as derived from ammonium sulfate. Though it is fast release, it does have the ability to release nitrogen in cooler soil temperatures compared to urea and other types of nitrogen. Also, since the N-form, NH_4^+ (ammonium) carries a positive charge, and clays and humus carry a negative charge, it is less likely to leach to ground water under some conditions. Sandy soils have a neutral to weakly negative charge, so ammonium sulfate is still prone to leaching if used at higher rates or when applications are poorly timed. On Nantucket sandy soils, especially those low in organic matter, ammonium sulfate is susceptible to leaching if improperly used or used in excess of the rate guidelines in Section 8.

Potassium nitrate – Potassium nitrate is a water-soluble, fast-release nitrogen source. This can be identified on a fertilizer label as percent nitrate derived from potassium nitrate. Because the N in potassium nitrate is already in nitrate form, it is immediately available for plant uptake, which benefits turfgrass and ornamental plants. However, being in the nitrate form also means that it is susceptible to leaching if improperly applied. Potassium nitrate is very susceptible to leaching if improperly used or used in excess of the recommended rates in Section 8.

Ammonium nitrate. Ammonium nitrate is a water-soluble, fast-release nitrogen source, already in both nitrate and ammonium form. It is expressed largely as percent nitrate, with some ammoniac nitrogen as well. It is typically a constituent of a larger blend of fertilizer, included with slow-release nitrogen (SRN). Ammonium nitrate alone is very difficult to purchase, and used mainly in agricultural applications. Ammonium nitrate is very susceptible to leaching if improperly used or used in excess of the rate guidelines in Section 8.

3. A. 2. Sources and Types of Slow-Release Nitrogen Fertilizers

Slowly available nitrogen sources are divided into the following three groups based on how their nitrogen is released; each of these groups contains a number of individual substances (listed) making the entire listing of slow-release nitrogen fertilizers very large.

Group I. Carbon-containing compounds are dependent on microbial decomposition for nitrogen release. Since microbial activity is dependent on soil temperature, these compounds are also temperature dependent, and therefore, nitrogen release should not be expected until soil temperatures warm up. It is noted that the maximum nutrient release occurs when soil temperatures are equal to or greater than 55°F, pH is around 6.5, and there is adequate moisture present; dry soils inhibit release. Within this group, there are two basic types of compounds; natural organic and ureaformaldehydes (UF) – sometimes referred to as synthetic organics. Because these UF's contain carbon in their structure, they are termed 'organic' in a scientific sense. But for the purposes of the Nantucket BMP, they are synthetic fertilizers and are not 'organic' in the ways the term is widely used.

1. Natural Organics – The nitrogen in natural organic fertilizers is derived from animal and plant by-products. Sewage based products are also used as natural organic fertilizers, though their use on Nantucket is discouraged because of heavy metal content. The majority of these sources allow for the slow release, or moderately-slow release, of nitrogen. However, there are sources that are considered fast release. Different natural organic nitrogen sources are explained further below, and are distinguished by their nitrogen release rate. It is noted that the sources based on animal protein may be attractive to meat eaters such as dogs, cats, skunks, and other foraging animals. These are only a handful of the many organic sources of nitrogen that are available for use as fertilizers.

   - Fast-release organic nitrogen sources

     - Blood meal – Derived from animal blood that is cooked, dried, and ground. It is a quickly available source of nitrogen. It is one of the highest non-synthetic sources of nitrogen and does have burn potential to the plant if used improperly. Though quick release, it does aid in balancing the carbon-nitrogen ratio, which is essential in building the soil. Blood meal also contains low amounts of phosphorus and potassium. It also serves as a good source of iron, a micronutrient necessary for plant health.

     - Meat meal – Meat meal is an organic, fast release source of nitrogen that is derived from the tissue of animals. Meat meal also contains phosphorus and iron.

     - Fish meal – Fish meal is an organic, fast release source of nitrogen derived from fish tissue. Fish meal also contains phosphorus and potassium.

     - Seaweed (Kelp Powder and Liquid Kelp) – Seaweed derived kelp powder and liquid kelp contain fast release N,P, and K, in small amounts, and micronutrients in high amounts. Liquid kelp is typically used in foliar applications.

   - Moderate to slow release organic nitrogen sources

- Fish meal – Fish meal is an organic, medium release source of nitrogen derived from fish tissue. Fish meal also contains phosphorus and potassium.
- Fish emulsion – Fish emulsion is an organic, medium to slow release source of nitrogen derived from fish waste. Emulsions are soluble, liquid fertilizers that are processed by heat and acid. They contain micronutrients as well.

- Fish hydrolyzate – Fish hydrolyzate is an organic, medium to slow release source of nitrogen derived from fish waste. Hydrolyzed liquid fish uses enzymes to digest the nutrients from fish instead of using heat and acid, allowing more vitamins, micronutrients, and proteins to be retained. Hydrolyzed fish contains phosphorus and potassium.

- Alfalfa meal – Alfalfa meal is an organic, medium to slow release nitrogen source that is derived from alfalfa. It contains phosphorus and potassium, as well as bio-stimulants. Alfalfa meal is frequently used to increase organic matter in the soil, but because it contains N-P-K it is considered a fertilizer as well.

- Crab meal – Crab meal is derived from the tissue of crabs and contains medium to slow release nitrogen. It also contains phosphorus, potassium, and calcium.

* Slow to very-slow release organic nitrogen sources

  - Bone meal – Bone meal is derived from the bones of poultry, beef, or pork and has been sterilized with intense heat. The actual amount of nitrogen is low, and bone meal is used more often as a source of phosphorus. If used as a nitrogen source, it is imperative to take into account the amount of phosphorus in bone meal. When using bone meal, the amount of phosphorus should be applied based on a soil test identified deficiency and recommendation.

  - Feather meal – Feather meal is an organic, slow release source of nitrogen that is derived from poultry waste. Feather meal can be high in nitrogen, but is slow to very slow in its release.

  - Seaweed (Kelp Meal) – Nitrogen derived from kelp meal is slow release. This type of seaweed has very little N-P-K and is more valuable for micronutrient content.

  - Cottonseed meal – Cottonseed meal is derived from cottonseed. Cottonseed meal also contains phosphorus and potassium, with a typical analysis of 6-2-2. Approximately 85% of its nitrogen is hot-water insoluble (HWIN) or slow release.

For discussions related to the Nantucket BMP, composts are considered to be fertilizer. Usually, compost is applied to build the soil and provide benefits other than fertilizer. But composts can contain varying amounts of nitrogen, phosphorus, and potassium, though typically low. The actual analysis of N-P-K varies with the many different sources of compost, and can even vary from batch to batch. Because of the differing sources and high variability of N-P-K amounts, compost is not listed above. Generally, composts are slow to release lower amounts of nitrogen and phosphorus, but testing of the compost should be conducted to more accurately account for the actual amounts of nitrogen and phosphorus applied.

2. <u>Ureaformaldehyde (UF) fertilizers</u> – UF fertilizers are synthetically derived, and are further divided into subgroups according to their release rates. For the purpose of distinguishing among slow-release nitrogen sources, it should be known that not all UF fertilizers are created equal – as explained below:

    - <u>Fraction I – Cold-Water Soluble Nitrogen (CWSN)</u> – CWSN nitrogen release is similar to fast-release nitrogen sources. Examples of CWSN compounds include shorter-chain methylene ureas. For the purposes of the Nantucket BMP, products that qualify as CWSN are considered fast-release nitrogen.

    - <u>Fraction II – Cold Water Insoluble Nitrogen (CWIN)</u> – CWIN nitrogen releases over several weeks. Intermediate-chain methylene ureas make up the majority of CWIN compounds.

    - <u>Fraction III – Hot-Water Insoluble Nitrogen (HWIN)</u> – HWIN release of nitrogen is very slow release, over months and even years. Nitrogen is in the form of long-chain methylene ureas.

Below are two examples of fertilizers containing these different 'fractions'. Please note that they are referenced by their brand name because that is how they are often identified by practitioners. This use of names is not an endorsement of any particular product.

- <u>Nutralene</u> – Nutralene is a mix of fast release nitrogen, slow release nitrogen, and methylene urea. Nutralene depends on temperature, microbial activity, and soil moisture to release the SRN portion of its product. Release is divided into thirds over a 16-week period. The first 6 weeks is mainly dependent on water soluble nitrogen, followed by slowly available nitrogen (SRN) in weeks 5-10, and finally the water insoluble component (WIN) in weeks 10-16.

- <u>Nitroform</u> – Nitroform is similar to Nutralene, in that it contains WSN, SRN, and WIN, but the WIN is in much greater percentage than Nutralene. The water soluble component is small, and releases over the first four weeks, followed by the SRN through weeks 4-8. Finally, the WIN component releases in weeks 8-22.

Group II. Carbon-containing compounds that have a low solubility in water. Nitrogen is released by the slow dissolution through water of the fertilizer particle. IBDU (Isobutylidene diurea) falls within this group. Group II fertilizers can release N in cooler soils than Group I..

IBDU – Isobutylidene diurea – IBDU nitrogen releases through a process called slow hydrolysis. The product has a lower solubility in water that allows for the controlled release of nitrogen. IBDU is the slow-release component in many products, and the percentages of slow release can vary from 25 percent to nearly 90 percent of total nitrogen. The remaining percentage is fast-release nitrogen, therefore it is important to ensure that no more than 0.25 lbs of N are in quick release form, dependent on the time of year applied, and in accordance with the table in Section 8.

Group III – These compounds are water soluble, but coated with a physical barrier of some type that delays nitrogen release. Examples of these barriers include polymer, plastic, and sulfur coatings. A discussion of each is below(This use of names is not an endorsement of any particular product):

Polymer Coated Urea – Examples of Polymer Coated Urea are Polyon and Osmocote. Polyon's typical nitrogen source is urea, which is encapsulated with a polymer membrane that diffuses nitrogen slowly by soil temperature. It is not dependent on moisture or microbial activity for nitrogen breakdown. The percentage of slow-release nitrogen (SRN) in their products varies, but can be as high as 100% of total nitrogen dependent on the analysis chosen. Osmocote is sealed with a plastic/polymer coating. The release of nitrogen is largely dependent on temperature, and to a lesser degree water. The release rate of nitrogen is mainly determined by the thickness of the plastic, the thicker the coating, the longer the release time.

Sulfur Coated Ureas (SCU) – SCU's vary according to their coating strength, and are designed to slowly break down with water. The best types of SCU's have coatings around the fertilizer particles that have no holes or cracks in the coating, allowing for a more controlled-release of nitrogen. The cheaper and weaker types of SCU are easily broken by mower traffic and have holes and cracks that allow for a more rapid release of nitrogen. Wax sealants are sometimes used to combat the quick break down of the coating. When a wax sealant is used, microbial activity must aid in the break down in addition to hydrolysis. When considering which SCU product to use, products with stronger coatings should be chosen.

3. B. Sources and Types of Phosphorus Fertilizer

Since most organic fertilizers contain phosphorus in addition to nitrogen, many sources of phosphorus are detailed in the prior category with nitrogen. Additional sources of organic and synthetic phosphorus are detailed below:

- Additional organic sources of phosphorus

    - Mushroom compost – Mushroom compost is derived from composted mushroom waste, often horse manure appropriately composted and aged, and has a very high phosphorus content. Its release time is slow, and though it contains nitrogen, the content is very low.

    - Bat guano – Bat guano is a good source of phosphorus, and also contains nitrogen and potassium. Its nitrogen release rate is fast to medium, so consideration of nitrogen rates and timing must be accounted for. Bat guano when used, is preferably included as part of a larger, slower release blend.

    - Worm castings – Beyond being a source of phosphorus, worm castings are excellent in building the soil by providing organic matter. Worm castings also contain small amounts of nitrogen and potassium.

    - Soft rock phosphates – Though not truly organic, soft rock phosphates are naturally derived from mining clay particles with natural phosphate. Soft rock phosphates are slow to very slow to breakdown. Dependent on sources, rock phosphates can correct phosphorus deficiencies for 3-12 years. They also contain calcium.

- Synthetic sources of phosphorus

    - Monoammonium phosphate (MAP) – MAP is a fast release source of phosphate, MAP also contains fast release nitrogen. As with other phosphorus sources that include nitrogen, if high phosphate corrections are necessary, the amount of nitrogen will increase as well. Nitrogen rates and timing must be accounted for when applying MAP. MAP's typical analysis is 11-52-0. Since this is a quick-release product, no more than 0.25 lbs of N/1000 sq ft can be applied at one time. With the typical analysis of 11-52-0, no more than 2.25 lbs of product per 1000 sq ft can be applied. This rate would allow still allow for over 1 lb. of phosphate, and 0.5 lb of actual phosphorus.

    - Diammonium phosphate (DAP) – DAP is a fast release source of phosphate which also contains fats release nitrogen. Similar to MAP because of its nitrogen content, caution should be taken if the purpose of using DAP is for correcting a phosphorus deficiency based on the results of a soil test. Its nitrogen release rate is fast, so consideration of nitrogen rates and timing must be accounted for. Dap's typical analysis is 18-56-0. Since this is a quick-release product, no more than 0.25 lbs of N can be applied at one time. With the typical analysis of 18-56-0, no more than 1.4 lbs of product per 1000 sq ft can be applied. This rate would allow for 0.78 lb of phosphate and 0.34 lb of actual phosphorus.

- Monopotassium phosphate (MKP) – MKP is a fast release source of phosphate and potassium. It contains no nitrogen, and is often used for foliar applications. MKP's typical analysis is 0-52-34.

- Triple super phosphate – Triple super phosphate is a fast release synthetic source of phosphate, and popular in greenhouse and garden uses. As with the above sources with high phosphate contents, following recommendations from a soil test identified deficiency is imperative for proper application.

3. C. Sources and Types of Potassium Fertilizer

- Greensand. Greensand is naturally derived from the deposits of minerals that were once part of the ocean floor. Greensand typically contains only potassium, but can sometimes contain small amounts of phosphorus.

- Sulfate of potash. Sulfate of potash is a naturally occurring mineral that is mined and an excellent source for addressing potassium deficiencies. It also contains sulfur, an element necessary for plant nutrition. It has a low burn potential.

- Langbeinite. Langbeinite is a naturally occurring mineral containing potassium that is mined from evaporated seawater. It also contains sulfur and magnesium, both required nutrients for plant nutrition. Langbeinite is often referred to as Sul-Po-Mag.

- Muriate of potash. Muriate of potash is a synthetic source of potassium that is popular in fertilizer blends due to its low cost of manufacturing. However, muriate of potash contains chlorine, which may negatively impact soil microbial populations. It also has a high burn potential on turfgrass. The use of muriate of potash is not recommended on Nantucket.

Appendix 4. Turfgrass Varieties and Cultivars Suitable for Nantucket

Kentucky Blue Grass. Kentucky blue grass has a fine-to-medium leaf texture and is dark green in color. Its growth habit is to spread via rhizomes making it a popular choice for sod farming. It has the ability to recover fairly easily from damage. Tolerance is high for wear and cold temperature, but moderate for heat and drought. This grass becomes semi-dormant very quickly under hot and dry conditions. It does recover quickly once cooler temperatures with adequate moisture return. Kentucky bluegrass is best grown in well-drained, sunny areas although a few cultivars will tolerate some shade. It requires higher amounts of nitrogen (2-3lb.N/1000sq. ft. annually) than some other cool-season grasses and may produce a significant amount of thatch if over-fertilized or over-watered. Kentucky bluegrass can be susceptible to diseases such as leaf spot, dollar spot, ring spot and summer patch. Some newer cultivars show some disease resistance.

Advantages-	Fast recovery from wear or abuse, Dense turf, Excellent cold tolerance, Dark green color.
Disadvantages-	Poor shade tolerance, Requires regular watering to maintain quality.

Perennial Ryegrass. Perennial ryegrass has a fine-to-medium leaf texture and tends to be dark green in color. It germinates rapidly and is quick to establish, making it suitable for over-seeding. It is competitive with other grasses, however, and is used either alone or in combinations with Kentucky bluegrass or fine fescues. Use no more than 20 percent perennial ryegrass when mixing with other grass species. It is wear and heat tolerant, but will not tolerate shade well. Perennial ryegrass does best on well-drained soils with moderate fertility. The nitrogen requirement for perennial ryegrass is approximately 2-3lb.N/1000sq.ft. annually, with little thatch accumulation. Perennial ryegrass is susceptible to diseases such as brown patch, Pythium blight, dollar spot, red thread, and rust. Several cultivars contain beneficial fungal endophytes, which provide some disease and insect resistance.

Advantages-	Fast establishment, Good wear tolerance.
Disadvantages-	Does not tolerate poorly drained soils, Requires full sun.

Fine Fescues. Fine fescues (Creeping Red, Chewing, and Hard Fescues) are narrow-leaved, medium-green to dark-green grasses that can be used alone or in combination with other grasses. Each species varies somewhat in terms of growth characteristics, but all are ideal for low-maintenance situations. They are very tolerant of low pH and fertility, and of drought and shade. Fine fescues become semi-dormant in heat and drought but recover quickly. These grasses require 1-2lbs.N/1000sq.ft. with minimal production of thatch. Fine fescues are susceptible to leaf spot, red thread and dollar spot. Endophytically enhanced cultivars have some resistance to dollar spot and insects. Cultivars without endophytes are highly susceptible to damage from chinch bugs.

Advantages-	Tolerates shade, Requires minimal fertility, Has low water requirements.
Disadvantages-	Susceptible to heat and drought, Poor wear tolerance and poor recovery rates.

Tall Fescues. Many new "Turf-type" tall-fescue varieties that are finer textured and darker green are a viable option for lawns. Tall fescue is slow to establish, preferring temperatures above 70 degrees F for optimal germination. It has only a fair recovery potential, but it is both drought and heat tolerant. Tall fescues perform best in well-drained soils in open sunny locations but can withstand moderate shade. Overall, tall fescues are more shade tolerant than Kentucky bluegrass and perennial ryegrass, but less so than fine fescues. Tall fescue requires 2.5-3lbs.N/1000sq.ft. with minimal accumulation of thatch. Most cultivars should not be mown at less than 2". Tall fescue is susceptible to brown patch, red thread and pythium blight.

Advantages-	Some shade tolerance, Has low water requirements, Good wear tolerance.
Disadvantages-	Not very cold tolerant.

Rough Bluegrass. If shade is an issue on the site, first consider whether turfgrass is appropriate for the location. It is possible that a shade-tolerant ground cover may be better able to adapt to shade. If turfgrass is used, rough bluegrass (Poa trivialis) may be a good choice as part of a mix with other turfgrass species. Rough bluegrass has proven to be a good alternative for shaded sites, but is rarely used by itself. Rough bluegrass has a medium leaf texture and tends to have a medium green color. It requires 1-2 lbs.N /1,000 sq.ft. annually. It is typically mown at a 2-3" height, which may be somewhat lower than needed for other lawn grasses, and adapts well to moist sites. It does not however tolerate traffic, drought, or heat well.

Advantages -	Excellent shade tolerance, Low fertility requirements.
Disadvantages-	Poor wear tolerance, Poor heat and drought tolerance. May segregate into clumpy patches.

Bentgrass. Creeping bentgrass has a fine leaf texture and is typically medium green in color. It is not an appropriate turfgrass for most lawns, but is used on croquet courts, golf courses, and bocce courts on Nantucket. It can be aggressive, and its growth habit is stoloniferous (producing runners), allowing it to recover rapidly from damage. It has moderate heat, shade, and drought tolerances. Creeping bentgrass is typically mown at heights between 1/8" and ½". It does require moderate irrigation and 2-3lb.N/1,000 sq.ft. Because of its high traffic use, it requires intensive cultural practices.

Advantages -	Excellent choice for very low mowing heights, Good recuperative ability.
Disadvantages-	Can produce heavy thatch levels, Prone to disease. Requires specialized maintenance to keep up quality.

Appendix 5. Spreader Calibration: A Step by Step Guide:

Step 1. Calculate the pounds of product necessary to spread. As an example, let's assume the decided rate is ½ pound of actual nitrogen per 1,000 square feet (0.5 lbs N/1,000 sq ft). For turfgrass applications, pounds per 1,000 sq ft is the most common way to describe the rate of fertilizer product, including nitrogen, and other nutrients. Pounds per acre (lbs/A) is sometimes used, especially with large applications of lime and compost.

The required amount of product (fertilizer) per 1,000 square feet must be calculated before applying the fertilizer. This can easily be achieved by knowing both the desired rate of nitrogen and the fertilizer analysis on the bag as described in Section 6. Using a hypothetical analysis of 10-0-8 (10 in the analysis = 10% nitrogen) and a desired nitrogen rate of 0.5lbs N/1,000 sq.ft., we would calculate the pounds of product (fertilizer) needed per 1,000 sq ft as follows:

$$\frac{\text{Desired N rate in lbs. N/1,000 sq. ft.}}{\text{Percent Nitrogen (decimal) in fertilizer}} = \frac{\text{Pounds of product needed}}{\text{1,000 sq.ft.}}$$

Using our desired N rate from above and the percent nitrogen in decimal form allows us to calculate below the necessary amount of product needed to spread over a lawn, etc.

$$\frac{\text{0.5 lbs N (desired N rate)}}{\text{0.10 (\% N in decimal form)}} = \frac{\text{5 lbs of product needed}}{\text{1,000 sq.ft.}}$$

Now we can calibrate the spreader for the hypothetical fertilizer analysis (formula) of 10-0-8 so as to give an Application Rate of 0.5lb.N/1000sq.ft.

Step 2. Weighing the required material for calibration. Once we have determined that 5 pounds of product (fertilizer) per 1,000 sq ft will be required to achieve our desired rate of 0.5 lbs of nitrogen per 1,000 sq ft, we need to calibrate the spreader. The most precise way to achieve calibration is to first weigh and load a known amount of fertilizer into the spreader. A basic rule is to load twice the amount of the desired rate of product; in this case that would be 10 pounds of fertilizer.

Step 3. Determining spreader swath width of fertilizer for calibration. After weighing a known amount (10 lbs.) of fertilizer into the spreader hopper, a swath width is determined by walking at normal speed and engaging the spreader. Measure the width of the fertilizer thrown from left to right to determine the swath width. Because spreaders throw slightly less fertilizer on the farthest sides, it is a good practice to overlap swaths slightly (6-12 inches). Let's assume that our swath width was 10 feet all the way across, which is a common width.

Step 4. Setting up calibration course. We now know our swath width (10 feet) and pounds of product needed per 1,000 sq ft (5) necessary to achieve our desired rate of 0.5 lbs of nitrogen per 1,000 sq ft. We now set up a 1,000 sq ft area for calibration. Dividing 1,000 by the 10-foot swath width, we get 100 feet; this is our "run." Measure out 100 feet being sure to mark the starting and ending points. Set the spreader using the setting on the bag as a starting point only. Each person using the same spreader walks at a different pace, each spreader has differing amounts of wear, and each site is different enough to not trust the setting on the bag solely. However, the bag setting for your desired rate and type of spreader can be a starting point.

Step 5. Walking the calibration course and completion. Begin walking and fertilizing at a normal pace until reaching the end point. After finishing this calibration course, empty the remaining fertilizer into the bucket and weigh the material using a scale. If you still have 5 pounds remaining, your calibration is perfect. If you have too much or not enough left, adjust the spreader setting, and repeat the calibration using a different calibration course. This is a very important point – using the same course can effectively double the amount of fertilizer applied in that area. This is not only harmful to the turfgrass, but allows for the possibility of leaching and/or runoff. Once proper calibration has been achieved, do not fertilize the calibration course or courses for the same reason as above. Of course, you can calibrate on a hard surface that allows for recovery of the fertilizer.

Appendix 6. Sample Record Keeping Sheet for Fertilizer Applications

NAME OF APPLICATOR:______________________________ LICENSE #__________________________

NANTUCKET - FERTILIZER RECORD

CUSTOMER: __________________ WEATHER CONDITIONS:____

LOCATION: __________________

		SQ. FT.	RATE	SP. SETTING	AMT. PROD.
DATE:	__________________				
PRODUCT:	__________________	______________	_____________	____________________	_____________
PRODUCT:	__________________	______________	_____________	____________________	_____________
PRODUCT:	__________________	______________	_____________	____________________	_____________

SITE OBSERVATIONS:____

Perhaps add:
Area of plants being fertilized: ______________
For Integrated Pest Management: Product also contains ______________ (specify pesticide)
Total N, P, K added by the end of the season.

Appendix 7. Examples of Three Turf Fertilizer Management Programs
Contributors: Jonathan Wisentaner; Michael Misurelli; Mark Lucas

An Organic Fertility Program

- 1st application, late fall of previous season. Apply dolomitic limestone as indicated by a soil test at rates up to 50 lbs per 1000 sq ft to raise pH and improve magnesium levels in late fall of the previous season, when possible, as lime takes up to 6 months to alter pH.

- 2nd application, spring. As soil temperatures reach 55 degrees F in spring (late April to mid May) apply natural sulfate of potash (0-0-50) at 1 lb per 1000 sq ft of actual potassium to improve potassium levels. Apply sulfate of potash, magnesia at 0.5lb per 1000 sq ft of actual potassium to improve potassium, magnesium and sulfur. Alternatively, use a dolomitic limestone in the step above to alter magnesium content if needed. Top dress with compost at a ¼" depth to increase the soil's organic matter level and supply a small amount of available nitrogen and microbiology.

- 3rd application, June 15. Apply an organic fertilizer blend of 6-0-6, at the rate of 1 lb nitrogen, N, per 1000 sq ft. A typical organic blend of 6-0-6 is made from sulfate of potash, natural nitrate of soda, peanut meal, feather meal, and pasteurized poultry litter. 75% of the nitrogen is water insoluble, or slow release.

- 4th application, July 15. Apply compost tea to supply beneficial micro-organisms, micro elements, and less than 0.1 lb nitrogen per 1000 sq ft.

- 5th application, Aug 15. Apply compost tea to supply beneficial micro-organisms, micro elements and less than 0.1 lb of nitrogen per 1000 sq ft.

- 6th application, Sept 1. Top dress with compost at a ¼" depth to increase the soil's organic matter level and supply a small amount of available nitrogen (est. 0.25 lb per 1000 sq ft) and microbiology. Combine this application with aeration and over seeding to increase turf density. If over seeding is practiced, some additional nutrition should be applied.

- 7th application, Sept 15. Apply the 6-0-6 organic blend, at a rate of 1 lb of nitrogen per 1000 sq ft. This 6-0-6 blend is normally made from sulfate of potash, natural nitrate of soda, peanut meal, feather meal and pasteurized poultry litter. 75% of the nitrogen is water insoluble, or slow release.

- 8th application, October 1. If the need is indicated by a soil test, apply natural sulfate of potash (0-0-50) at a rate of 1 lb K per 1000 sq ft of actual potassium to improve potassium levels.

Totals for the season:

Nitrogen- 2.75 lb per 1000 sq ft,
Phosphorus- Minimal if low-phosphorus compost used,
Potassium- 4.5 lb per 1000 sq ft,
Sulfur- 0.5 lb per 1000 sq ft,
Magnesium- 0.5 lb per 1000 sq ft.

A Synthetic Turf Fertilizer Program

The following program consists of products that contain synthetic sources of nitrogen.

- 1st application, late fall of previous season. Application of dolomitic limestone at 50 lbs per1000 sq ft to raise pH and improve magnesium levels in late fall of the previous season, if possible, as lime takes up to 6 months to alter pH

- 2nd Application, May 15th. Apply 30-0-7 Polyon with 60% slow-release nitrogen at a rate of 1 lb actual N per thousand sq ft.

- 3rd Application, July 1. Apply (15-0-8) Nature Safe at a rate of 1 lb of actual N per 1000 sq ft.

- 4th Application, August 15th. Apply a synthetic fertilizer (29-0-10) with 70 % slow-release Nitrogen at the rate of 1 lb of actual N per 1000 sq ft.

- 5th Application, October 1st. Use (15-0-8) Nature Safe and apply at the rate of 0.5 lb of actual N per 1000 sq ft.

Totals for the season:

Nitrogen – 3.25 lbs. per 1,000 sq ft, 74% of which is slow release and 47% organic,
Phosphorus – 0.15 lbs. of actual phosphorus per 1,000 sq ft,
Potassium – 4.65 lbs. of actual potassium per 1,000 sq ft.

Hybrid fertilizer program – Spoon feeding

The following program consists of products that contain both organic and synthetic sources of nitrogen. The assumption is that phosphorus levels are normal, as indicated by a soil test above, and that magnesium and potassium are deficient. Some of these products below are 'bridge products' – which contain both organic and synthetic materials. This program emphasizes the spoon feeding of nitrogen.

- 1st application. May 14th – Apply Contec DG, 6-0-12, 0.24 lb. of nitrogen per 1,000 sq.ft., 100% quick release. Also contains manganese sulfate (which will provide enhanced green color similar to iron sulfate) and magnesium sulfate to increase magnesium levels. This product allows for 4 lbs. of product to be spread

- 2nd application. June 4th – Apply SeaBlend, 12-4-5, 0.48 lb. of nitrogen per 1,000 sq.ft., 50% slow release. SeaBlend is a bridge product that is 50% organic and 50% synthetic. Urea and methylene urea (slow release) make up the synthetic portion of this product. Organic sources of nitrogen include kelp meal, fish meal, crab meal, alfalfa meal, poultry meal, and blood meal. These sources include quickly available and slow-release sources of nitrogen. A small amount of phosphorus is included in this product. Also contains ferrous sulfate for color and magnesium sulfate to increase magnesium levels.

- 3rd application. July 2nd – Apply SeaBlend, 12-4-5, 0.48 lb. of nitrogen per 1,000 sq.ft., 50% slow release.

- 4th application. August 6th – Apply SeaBlend, 12-4-5, 0.48 lb. of nitrogen per 1,000 sq.ft., 50% slow release.

- 5th application. September 3rd – Apply Contec DG, 6-0-12, 0.24 lb. of nitrogen per 1, 000 sq.ft., 100% quick release.

- 6th application. September 24th – Apply Contec DG, 6-0-12, 0.24 lb. of nitrogen per 1, 000 sq.ft., 100% quick release.

Totals for season:

Nitrogen – 2.16 lbs. per 1,000 sq.ft., 33% of which is slow release, 33% organic (also slow release).
Phosphorus – 0.21 lbs. of actual phosphorus per 1,000 sq.ft. (0.48 lbs. in phosphate form).
Potassium – 0.50 lbs. of actual potassium per 1,000 sq.ft. (0.60 lbs in potash form).

Appendix 8. List of Common Documents

The starting point for the Article 68 Work Group was the tremendous amount of technical and legal material that had been assembled by others who were concerned for the quality of their ground and surface waters. These documents were collected into a file of common documents, which is reproduced here both to credit those who came before the Article 68 Work Group and to archive our beginning.

ARTICLE 68 WORK GROUP
The Fertilizer Committee

REFERENCE LIST OF COMMON DOCUMENTS
As of June 30, 2010
Compiled by Lee W. Saperstein

Documents Providing Authority

Massachusetts, Commonwealth of, Department of Environmental Protection (DEP), "Nonpoint Pollution Source (NPS) Management Plan," Found on May 16, 2010 at URL: www.mass.gov/dep/water/resources/nonpoint.htm.

> The plan itself is hot linked from this menu page and can be downloaded as a Word or PDF document. In the Executive Summary, page 12, it says that a DEP objective is to assist "communities in drafting river protection bylaws and ordinances."

Massachusetts, Commonwealth of, Department of Environmental Protection (DEP), Water, Wastewater, & Wetlands, "Coastal Resources & Estuaries," A web page with links to explanations on the Massachusetts Estuaries Project (MEP) and reports published or planned; found on May 16, 2010, at URL: http://www.mass.gov/dep/water/resources/coastalr.htm#reports. The web page for "What are Estuaries?," http://www.mass.gov/dep/water/resources/brochure.htm, explains why nitrogen loading is a problem for estuaries and then states, as part of the suggestions for a solution, that "including limiting use of lawn fertilizers" may be necessary.

Massachusetts, Commonwealth of, Executive Office of Energy and Environmental Affairs, Nantucket Harbor Embayment System, Total Maximum Daily Loads for Total Nitrogen, Report # 97-TMDL-2 Control #249.0, 32 pages, January 28, 2009. Found on May 16, 2010, at URL: http://www.mass.gov/dep/water/resources/nantuckt.doc.

> This final report on the quality of water in Nantucket Harbor is the most quantitatively definitive on nitrogen (nutrient) loading. It is part of a series of reports that comprise the Massachusetts Estuaries Project (q.v.).

Nantucket, Town of, Annual Town Meeting, April 5-7, 2010, Warrant Article 68, found on May 16, 2010, at URL: http://www.nantucket-ma.gov/Pages/NantucketMA_TownMeeting/2010atm/2010ATMwarrantFCmotionsFINAL.pdf.

This is the Article as proposed by the Board of Selectmen on behalf of the Harbor Plan Implementation Committee (HPIC). It was amended substantially on the floor of the ATM whereby the Town removed most of the technical language of the Article and left the request that the Town write a Home-Rule Petition for the control of fertilizer with the intent of presenting it to the Commonwealth in time for the next legislative session of the General Court. As amended and passed (ATM 10 ART 68 Fert HR(2).doc), this article provides the foundation for the Work Group.

Nantucket, Town of, The Nantucket and Madaket Harbors Plan Review Committee and the Department of Marine and Coastal Resources, Nantucket & Madaket Harbors Action Plan, 204 pages, May 2009 (As approved by the Secretary of the Massachusetts Executive Office of Energy and Environmental Affairs, December 21, 2009). Found on May 16, 2010, at URL: http://www.nantucketharborplan.com/.

In the letter of approval (12 pages, included as a preface to the Plan), the Secretary listed a number of federal policy principles to which adherence should be maintained. He said, "The federally-approved CZM Program Plan establishes 20 enforceable program policies and 9 management principles which embody coastal policy for the Commonwealth of Massachusetts." Relevant to the purposes of the Work Group is this quotation,

> "• Water Quality Policy #2: Ensure that non-point pollution controls promote the attainment of state surface water quality standards in the coastal zone."

The section of the 2009 Harbor Plan that is relevant to the Work Group is Section 2.2, "Water Quality," p. 18 et seq.

Ordinances from other Jurisdictions that Control Fertilizer Use

Dane, County of, Wisconsin, State of, Ordinances, "Establishing Regulations for Lawn Fertilizer and Coal Tar Sealcoat Products Application and Sale," Chapter 80; found on May 19, 2010, at URL: http://danedocs.countyofdane.com/webdocs/pdf/ordinances/ord080.pdf.

Minnesota, State of, Department of Agriculture (MDA), "Phosphorus Lawn Fertilizer Law, " a web brochure, 3 pages; found on May 19, 2010, at URL: http://www.mda.state.mn.us/phoslaw. It provides a link to Chapter 18C of the Minnesota State Statutes, "Minnesota's Fertilizer, Soil Amendment, and Plant Amendment Law" at https://www.revisor.mn.gov/revisor/pages/statute/statute_chapter_toc.php?year=2006&chapter=18C.

New Jersey, State of, Department of Environmental Protection, Division of Water Quality, Bureau of Nonpoint Pollution Control, http://www.state.nj.us/dep/dwq/bnpc_home.htm, provides information about nonpoint pollution sources including a fertilizer "tip" card: http://www.state.nj.us/dep/dwq/pdf/tipcard_fertilizerfinal.pdf.

New Jersey, State of, Department of Environmental Protection, “CleanWaterNJ,” provides advice to individuals and home owners, such as this page on gardening: http://www.cleanwaternj.org/garden.html.

New Jersey, State of, Department of Environmental Protection, Division of Watershed Management, “Rules and Guidance,” http://www.nj.gov/dep/watershedmgt/rules.htm, “Fertilizer Application Model Ordinance,” http://www.nj.gov/dep/watershedmgt/DOCS/TMDL/Fertilizer%20Application%20Model%20Ordinance.pdf.

Sanibel, City of, Florida, State of, “Welcome to Sanibel’s Fertilizer Information Website,” http://www.sanibelh2omatters.com/fertilizer/; includes links to their fertilizer control ordinance and their various educational, licensing, and outreach efforts.

Suffolk, County of, New York, State of, Department of Environment and Energy, “Suffolk County Fertilizer Reduction Initiative,” a web brochure found on May 19, 2010, at URL: http://www.suffolkcountyny.gov/departments/EnvironmentandEnergy/fri.aspx. This web site has links to their web page for “Healthy Lawns/Clean Water” at http://suffolkcountyny.gov/healthylawns/ and to their local law referenced separately below.

Suffolk, County of, New York, State of, “Local Law No. 41-2007, Suffolk County, New York: A Local Law to Reduce Nitrogen Pollution by Reducing Use of Fertilizer in Suffolk County; “ found on May 19, 2010, at URL: http://legis.suffolkcountyny.gov/resos2007/i2117-07.htm.

Westchester, County of, New York, State of, “Article XXVI, Chapter 863, Laws of Westchester County, Restrictions on the Application and Sale of Lawn Fertilizer within the County of Westchester;” 863-1301 to 863-1309, found on May 19, 2010, at URL: http://www.westchestergov.com/pdfs/ENVFACIL_2008LawnFertilizerLaw.pdf.

Westchester, County of, New York, State of, “Phosphorus Fertilizer Ban,” a web brochure found on May 19, 2010, at URL: http://www.westchestergov.com/printerfriendly/environment_fertilizerban.htm.

Documents that Further Define the Problem and/or Give Solutions

Nantucket Landscape Association, et al., “Best Management Practice for Turf, Tree, and shrub Fertilization on Nantucket Island,” 18 pages, February, 2003.

United States Department of Agriculture (USDA), Natural Resources Conservation Service, (NRCS), "Core 4. Conservation Practices Training Guide: The Common Sense Approach to Natural Resource Conservation," Part II. "Nutrient Management." 395 pages, August 1999. Found on May 16, 2010, at URL: http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf.

The technical reference section of the NRCS is immense. The Electronic Field Office Technical Guide is accessed by individual location so as to give the best reference for a particular locality. Its menu provides links to all resource conservation topics. A starting point is http://www.nrcs.usda.gov/technical/efotg/.

USDA, NRCS, National Handbook of Conservation Practices (NHCP), Conservation Practice Standard, "Nutrient Management," Code 590, 8 pages, August 2006. Found on May 16, 2010, at URL: http://nrcs.usda.gov/technical/standards/ and then open menu for national standards and then slide down to nutrient management or go directly to ftp://ftp-fc.sc.egov.usda.gov/NHQ/practice-standards/standards/590.doc.

The NHCP is the go-to reference for federal guidance on agricultural conservation: http://www.nrcs.usda.gov/technical/standards/nhcp.html.

United States Environmental Protection Agency, State-EPA Nutrient Innovations Task Group, "An Urgent Call to Action," August 2009, 170 pages. Found on May 16, 2010, at URL: http://www.epa.gov/waterscience/criteria/nutrient/nitgreport.pdf.

Background Documents including those Submitted by Members of the Committee and the Public

Buzzards Bay National Estuaries Program (BBNEP), "Nitrogen Pollution in Buzzards Bay," a web page found on May 16, 2010, at URL: http://www.buzzardsbay.org/nitrogen-pollution.htm, including "Nitrogen Management Strategies and Tools," also found on May 16, 2010, at URL: http://www.buzzardsbay.org/bbpnitro.htm.

Coffin, A, Chair, Committee on Long Pond and Madaket Ditch, "Report of the Committee," 24 pages, Voted to be published by Annual Town Meeting of March 22, 1882 , and published on March 28, 1882.

Cole, M. L, et al., "Effects of Watershed Land use on Nitrogen Concentrations and δ^{15} Nitrogen in Groundwater," Biogeochemistry, Springer Netherland, Vol. 77, No. 2, page 199-215, Feb 2006.

Horsley Witten Group, "Evaluation of Turfgrass Nitrogen Fertilizer Leaching Rates in Soils on Cape Cod, Massachusetts," Private report prepared for MassDEP, 33 pages, June 29, 2009.

Howes, B. L. et al., Woods Hole Oceanographic Institute (WHOI), "Nantucket Harbor Study: A Quantitative Assessment of the Environmental Health of Nantucket Harbor for the Development of a Nutrient Management Plan," Final Report, 50 pages plus un-paginated tables, figures, references, and appendix, March 1997.

Lehman, J. T. et al., "Evidence for Reduced River Phosphorus Following Implementation of a Lawn Fertilizer Ordinance," Lake and Reservoir Management, Taylor and Francis, London, Vol 25, 9 pages, 2009.

Massachusetts, Commonwealth of, Department of Environmental Protection (DEP), Massachusetts Estuaries Project, Howes, B., et al., "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Nantucket Harbor, Town of Nantucket, Nantucket Island, Massachusetts," Final Report, 183 pages, November 2006. Found on May 16, 2010, at URL: http://www.oceanscience.net/estuaries/report/Nantucket/Nantucket_Hbr_MEP_Final.pdf.

Massachusetts, Commonwealth of, Department of Environmental Protection (DEP), Massachusetts Estuaries Project, Howes, B., et al., "Linked Watershed-Embayment Model to Determine Critical Nitrogen Loading Thresholds for Sesachacha Pond, Town of Nantucket, Nantucket Island, Massachusetts," Final Report, 107 pages, November 2006. Found on May 16, 2010, at URL: http://www.oceanscience.net/estuaries/report/Sesachacha/Sesachacha_MEP_Final.pdf.

Nantucket, Town of, Board of Selectmen, Nantucket Harbor Watershed Work Group, "Report of the Nantucket Harbor Watershed Work Group," 38 pages, June 1, 2003. Paper copy only.

Nantucket, Town of, Marine and Coastal Resources Department, Annual Reports on Water Quality; paper only:

> Conant, K. L., "Hummock Pond, Annual Report, 2006," 26 pages, March 2007;
> Conant, K. L., "Hummock Pond, Annual Report, 2007," 26 pages, March 2008;
> Conant, K. L., "Nantucket Harbor Water Quality, Annual Report, 2006," 39 pages, January 2007;
> Conant, K. L., "Nantucket Harbor Water Quality, Annual Report, 2007," 38 pages, December 2007.

NOFA Organic Land Care Committee, S. Little, Chair, "NOFA Standards for Organic Land Care: Practices for Design and Maintenance of Ecological Landscapes," Northeast Organic Farming Association (NOFA), 4th Edition, 88 pages, April 2009. Found May 16, 2010, at URL: http://www.organiclandcare.net/sites/default/files/upload/NOFA_Standards_4th_ed_2009.pdf.

Petrovic, A. M., "Report to the Pleasant Bay Alliance on the Turfgrass Fertilizer Nitrogen Leaching Rate," Self published, 11 pages, August 2008. Dr. Petrovic is with the Cornell University Agriculture Extension Service and has published a series of research reports on nitrogen in ground water. Suffolk County, NY, referenced above, relied on his research extensively.

Tomer, M. D. and M. R. Burkart, "Long-Term Effects of Nitrogen Fertilizer Use on Ground Water Nitrate in Two Small Watersheds." Journal of Environmental Quality, Vol. 32, pages2158–2171 (2003).